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THE GUERNSEY.

THE more sharp definitions that now divide into especial breeds the animals that originated, and have long been imported from the islands of the English Channel, are bringing to the attention of breeders and dairymen the different traits and characteristics of the cattle long and most favorably known under the common name of Alderneys. It is supposed that the name of the small island of Alderney gained application to the cattle from both Guernsey and Jersey, from the fact that vessels cleared from that port last, and were announced on their arrival in England as from Alderney.

The number of cattle exported from that island is comparatively limited, and we are now called upon to consider as the sources of our Channel Island cattle only Guernsey and Jersey, the main islands in size and importance, and the only ones where the cattle have been guarded and bred with a persistent care that has hardly been given to any other class of domestic animals.

From colored illustrations and careful descriptions, in the finest and most reliable volumes on cattle it is found that it is evidently within half a century that the characteristics which now distinguish the Guernsey and Jersey cattle have been produced by skillful breeding, with different aims in view. On the Island of Jersey the cattle have been bred more and more to supply the British demand for a pet cow that on the green lawns surrounding their country places would show as a beautiful object. For many years a light squirrel-gray was deemed a color well fitted to contrast with the deep green of English grass. A later fancy has called for animals of dark color, which to be entirely fashionable must add to their attractions black points and a black tongue. But the sturdy Guernseyman has departed less in his breeding from the original type of his butter cow. A century ago her merits were so fully appreciated that it was determined that the introduction of any foreign blood was undesirable, and in 1789 a law was passed by the insular legislature forbidding the importation of any cow, heifer, bull, or calf under a penalty of 200 livres, and the forfeiture of the boat and tackle which should bring them, and a further penalty of 50 livres on any sailor on board who should fail to inform of the importation. Since that date it is probable that the cattle of the Island of Guernsey have remained as absolutely pure as any breed that is known. The aim that has animated these many years of care has been to produce a cow as perfect as possible for the dairy of luxury—a cow to produce milk and cream of marvelous richness, and butter that in grain, flavor, and golden color excels that of any and all other breeds. The most remarkable characteristic of the Guernsey is the richness of the animal. It is seen in every point. The horn is soft and full of color; the hoofs are usually like tortoise-shell; the skin is soft and of a golden yellow tint, and the inside of the ears is still more highly colored, while the same orange hue seems to glow from the bag, as if there were light under the soft skin. In the mature, well bred animal, both eye and hand find evidence that all secretions are rich and of high quality, and a careful examination prepares the mind for understanding why the butter made from Guernsey cream possesses qualities that are not obtainable from the milk of any other animal. The disposition of these cattle is remarkably gentle and affectionate. On the island their care is usually confided to women and children, whose gentle ways are reflected in the quiet demeanor of their family favorites. Almost all the milk produced by the cattle of Guernsey is made into butter. This butter is carried to the handsome stone market building of St. Petersport, where the matrons sit awaiting their customers with their pats of golden butter daintily displayed in the deep green leaves of the Guernsey cabbage. It invariably commands the highest price on the island and in England. When the proprietor of Fernwood Farm was there, its price was 18 cents per pound above that made on the sister island of Jersey. The cattle on the island are in almost all instances tethered, and have but very little food beyond the grasses that in so moist a climate afford pasturage during nearly all the year. Although little or no grain is fed, the yield of butter from a mature Guernsey cow is expected to average a pound a day for the year, and there are many trustworthy statements of cows making 14 and 15 Guernsey pounds of butter, equal to 16 and 18 pounds of our weight, per week, without the forcing food that in this country has ruined many a fine cow by unnatural stimulation for the purpose of making a great butter record.

THE GUERNSEY BREED.

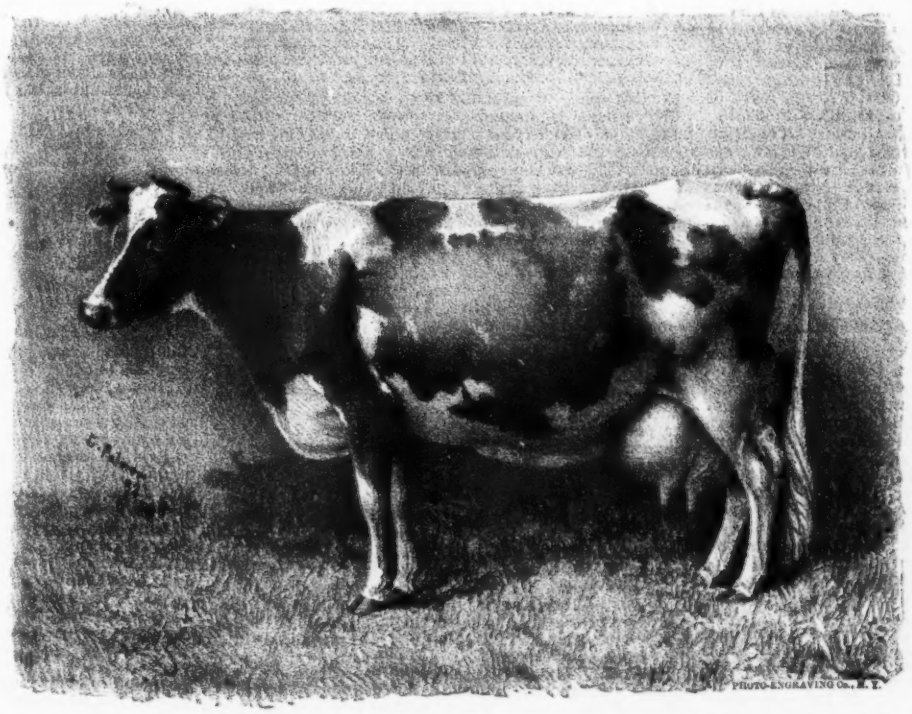
The milk yield of the Guernsey will compare favorably with any. The richness of the milk and cream is quite as marked as that of the Jersey; the color, especially in winter, is much more golden, and when mingled with the milk of ordinary cattle it will do much more to give color and character to butter. Among the Fernwood herd are animals that are stated to have given 40 pounds of milk with first calf, and as high as the vicinity of 10,000 pounds in a year. Of this milk, when in full flow, 22 pounds will make a pound of butter, and later in the flow the amount is lessened to 16 to 18 pounds.

The long inherited purity of a class of cattle is an element in breeding of far greater value than is generally supposed. There is, as is well known to scientific men, a tendency in all young animals to develop the traits of a remote, rather than those of an immediate ancestor.

The commingling of various or even quite antagonistic strains of blood may produce animals of very unusual individual merit, but such traits are not fixed, nor prepotent, and any one using such beasts for stock purposes will learn to his cost that the traits of the different sires and dams will come out in the most unexpected manner, confusing all plans and defeating success. But with thoroughbred animals of long guarded breeding, the traits are fixed, and no "striking back" to remote crosses can bring out doubtful features. In the case of the Guernseys, that are probably the most pure bred of any cattle, the overruling of their strong breeding is remarkable, one cross often producing cattle that experts cannot distinguish from full bloods, so strongly are they marked with the orange fawn color, golden and soft skins, and horns and hoofs full of rich tints.

Speaking of the Guernseys at last year's exhibition, Prof. Henry E. Alvord, of Houghton Farm, says in the New York *Weekly Tribune:*

"The favorite Jersey is not the only cow of the Channel Islands. For months *the Guernsey* has been rapidly advancing in favor and in market value, and the thirty-two animals of this breed shown at the New York State Fair fully justify all that their most ardent admirers claim for them. Larger in frame and a little coarser in form, these Guernseys more than rival the same number of picked Jerseys in richness of color, fineness of skin, and prominence of the best dairy points. They lack some of the deer-like beauty and grace of the Jersey, but their mild and contented faces are equally attractive. The Guernseys are plainly the larger milkers, and their milk gives a cream even deeper in color, if not greater in quantity. The bulls seem to have the same mild disposition, and are easily managed. Mr. Ledyard, of Fernwood Farm, Cazenovia, N. Y., took the first premium in all of the nine classes in which this stock was entered. As showing the power of Guernsey sires in reproducing the characteristics of this breed when used upon common stock, two grades attracted much attention and received a special premium. The most signal victory for the Guernsey at this fair, however, was the award of the sweepstake for the best milch cow of any kind, to Elegante, an imported cow, owned by Mr. Ledyard. The competitors were Shorthorns, Devons, Holsteins, and Jerseys—some of the best cows on the ground—but the Guernseys easily won the dairy honors. If they prove to be as robust as they appear, and can be 'turned' for beef as easily as is claimed, the Guernsey will deservedly become the favorite cow in the butter making sections of America."



ELEGANTE 592, OF FERNWOOD.—IMPORTED GUERNSEY.—SWEEPSTAKES WINNER OVER ALL BREEDS, N. Y. STATE FAIR, 1881.

GROWING POWER OF THE UNITED STATES.

PRIOR to our civil war the power of the United States was not regarded in Europe as formidable, either from a commercial or military standpoint, but there has been a remarkable change in European sentiment within the last twenty years. The great conflict between the North and the South drew special attention to the extraordinary physical strength of the country. A struggle protracted for four years upon a scale that amazed the Old World naturally aroused interest in the young giant that had grown up within a century. America was no longer deemed a mere struggling confederation of States, engaged upon the experiment of the republican form of government, but a grand, consolidated nation, able to maintain its supremacy in any and all directions. The war opened the eyes of the world to its unparalleled power and greatness. Twenty-five years ago, Europe knew the United States principally through its cotton, tobacco, and a few other agricultural staples. The United States to-day helps materially to feed and clothe the world. Strong and

impressive facts such as these, backed by fifty-odd millions of people, will inspire respect from the greatest of nations. Such far-seeing statesmen as Gladstone, the British Premier, have pointed to the growing power of the United States and its vast and varied resources, while the leading English journals have repeatedly attested the wonder with which the progress of this republic inspires Europe. "Statesmen and economists," says the *Pall Mall Gazette*, "ought to follow with great attention the marvelous phenomenon of the economical and material progress of the United States, since it must have no slight influence for good or evil on Europe. If our old continent should be in the form of the United States of Europe, without army and navy, and should be rapidly diminishing its debt, like the United States of America, we could more easily compete with them. But only socialists seem to be able to entertain such a dream." The past two decades have been remarkably busy with the development of resources in this country, and it is reasonable to anticipate that the next two decades will witness still greater achievements in material progress and national supremacy.

History affords no parallel to the wonderful increase of realized wealth in the United States during the last twenty years, a period which has witnessed the principal construction of our present magnificent railroad system, to which is mainly due the active development of our incomparable agricultural, mineral, and other vast resources during that period. Forty-two years ago, the wealth of Great Britain was computed to have been fivefold greater than ours, whereas at the present time it is conceded by Mr. Mulhall, an English statistician, that the wealth of the United States exceeds that of either Great Britain or France, though the average wealth per capita here is still less than in those countries. One evidence of the rapid increase of realized wealth in this country is the marked reduction in the rate of interest. Money has been materially cheaper here during the last ten years than it has ever been before. Upon undoubted security any amount of money is available, in a normal condition of affairs, at 3 to 4 per cent. This is not a matter of temporary moment; in the nature of things it is likely to be permanent, not only because there is now so much accumulated capital in this country, but because there is so much European capital seeking investment, with every prospect of an increase of such amount as the intrinsic value of our railroad and other investments become more thoroughly established in Europe, and sound judgment takes the place of speculation there. There will be, of course, seasons of depression and of panic; it is impossible, according to all commercial experience, to prevent these; they are the result of perfectly well understood and inevitable laws. But the question is, whether the nation is actually gaining wealth, all things considered; whether it is cultivating more land, or cultivating it better, producing more grain, horses, cattle, beef, pork, and exportable products. And that this question has already been decided affirmatively by abundant and cumulative evidence is attested by the immense tide of immigration and the heavy influx of capital in this direction from Europe. The country, it may be said, has but just begun to develop its resources. There is room here for a population many fold larger than the present, with the farmer lord of the land he tills. As the location of manufacturing centers shifts from age to age, the only permanent basis for population is the soil; and of that the United States has an immense excess over the ratio of population to the square mile which succeeds in making a living in older countries. The optimistic view of the future of the country is well founded. There are here and there facts and tendencies which, as to certain classes and sections, look the other way; but they are nothing as compared with the grand sweep of the continent and the irrepressible activity and intelligence of the people at large.—*Shipping List.*

LONG REIGNS.

THE celebration, March 22, of the eighty-sixth birthday of Emperor William of Germany, led to an examination of the records of crowned heads to find if possible a parallel to the German Emperor's longevity. The only ones discovered were Hiero II. of Syracuse, and Masinissa of Numidia, both of whom ended their reigns at about ninety years of age.

Among the remarkably long reigns in history are those of Uzziah of Judah (fifty-two years), Mithridates of Pontus (fifty-seven), Sapor II. of Persia (seventy-one), Alfonso I. of Portugal (seventy-three), Frederic III. of Germany (fifty-three), Christian IV. of Denmark (sixty), Louis XIV. of France (seventy-two), George III. of England (fifty-nine), Ferdinand IV. of Naples (sixty-five), and Pedro II. of Brazil (fifty-one till now). But Uzziah was a youth when he was placed on the throne, Mithridates a boy, Sapor a newborn babe, Alfonso an infant, Christian eleven years old, Louis four, Ferdinand nine, and Pedro five; and of all the monarchs mentioned, only George III. reached the age of fourscore, Poland had one king who lived to the age of eighty-eight. Stanislas Leszczynski; but he reigned only five years, and survived his throne fifty-six years, living in quiet retirement.

CAMBODIAN ANTIQUITIES.

IN the end of last year M. Delaporte went out to Cambodia, commissioned by the French Government and supported by that of Cochin China, for the purpose of exploring further the mysterious and gigantic architectural remains which abound in Cambodia, the origin and purpose of which have so exercised archæologists. M. Delaporte was accompanied by a large staff, and on his arrival at Phnom-Penh, the capital of Cambodia, proceeded directly to the celebrated ruins of Angkor. These he examined with great minuteness, and according to a just-published statement, believes he has been able at last to solve the difficult problem of the purpose of the religious buildings of this ancient metropolis of Indo-Chinese civilization. His discoveries have led him to the interesting and unexpected conclusion that these ancient Khmer temples were dedicated to Brahminism. At Angkor-Wat he detached from the higher parts the *chefs d'œuvre* of Cambodian sculpture; bass reliefs, once brilliantly gilt; pediments, all the subjects of which M. Delaporte maintains, down to those which decorate the most secluded sanctuary, are devoted to the exploits of Rama and the glories of Vishnu. At Angkor-Tom, M. Delaporte visited several new monuments, on most of which he also finds on the principal pediments the exploits of Rama and Vishnu. He believes he has proved the presence of the *lingo*, the emblem of Siva. He cleared of rubbish and explored the ancient palace of the Khmer kings, a work of magnificent and wonderful sculpture, the rising terraces of which are adorned with superb compositions in bass-relief; the enormous three headed elephant, Iravalti, is there enthroned in all the places of honor, as at the angles of all the gates of the city, where he is shown by the god Indra, accompanied by two *apsaras*, or celestial *danseuses*, of his paradise. M. Delaporte had already collected 300 photographs, 40 mouldings, and a small number of original specimens of great value, when he and some of his staff were compelled to return to Saigon in ill-health; thence M. Delaporte sailed for France. The work of excavation and exploration has, however, been carried on by a substitute in the absence of M. Delaporte. Since the latter's departure much additional work has been done in photographing, moulding, and collecting specimens. The detailed results of this fresh work on these celebrated ruins will be looked for with interest by archæologists. So far as we are aware a Brahminical origin has never been attributed to them, though a solution has been sought both in Buddhism and serpent-worship.—*London Times.*

THE PREPARATION OF SIRUPS.*

IN the preparation of sirups, which are solutions of sugar, more or less strong according to the object for which they are used, care should be taken to employ only the best refined sugar, and either distilled or filtered rain water, as they will be rendered much less liable to spontaneous decomposition, and become perfectly transparent without the trouble of clarifying. When, however, impure sugar is employed, clarification is always necessary. This is best done by dissolving the sugar in the water or fruit juices cold, and then beating up a little of the cold sirup with some white of egg and one or two ounces of cold water, until the mixture froths well; this must be added to the sirup in the boiler, and when the whole is frisked up to a good froth, heat should be applied, and the scum which forms removed from time to time with a clean skimmer. As soon as the sirup begins to simmer it must be removed from the fire and allowed to stand until it has cooled a little, when it should again be skimmed, if necessary, and then passed through a clean flannel. By using refined sugar, however, all this trouble of clarification can be avoided.

When vegetable infusions or solutions enter into the compositions of sirups, they should be rendered perfectly transparent be filtration or clarification, before being added to the sugar.

The proper quantity of sugar for sirups will, in general, be found to be two pounds avoirdupois to every pint of water or thin aqueous fluid. These proportions allow for the water that is lost by evaporation during the process and are those best calculated to produce sirup of proper consistence and possessing good keeping qualities. They closely correspond to those recommended by Guibourt for the production of a perfect sirup, which, he says, consists of 30 parts of sugar to 16 parts of water.

In the preparation of sirup it is of great importance to employ as little heat as possible, as a solution of sugar, even when kept at a temperature of boiling water, undergoes slow decomposition. The best plan is to pour the water (cold) over the sugar, and to allow the two to lie together for a few hours, in a covered vessel, occasionally stirring, and to apply a gentle heat, preferably that of steam or of a water-bath, to finish the solution. Sirups are sufficiently boiled when some, taken up in a spoon, pours out like oil, or a drop cooled on the thumb nail gives a proper thread when touched. When a thin skin appears on blowing the sirup, it is judged to be completely saturated. These rude tests, however, often lead to errors, which might be easily prevented by employing the proper proportions, or determining the specific gravity by immersing in the sirup one of Baumé's saccharometers or sirup gauges, as indicated in the following table:

Sugar in 100 parts.	Sp. Gr.	Deg. Baumé.
0	1·000	0
5	1·020	3
10	1·040	6
15	1·062	8
20	1·081	11
25	1·104	13·5
30	1·128	16·3
35	1·152	19
40	1·177	21·6
45	1·204	24·5
50	1·230	27
55	1·257	29·5
60	1·284	32
67	1·321	35

A fluid ounce of saturated sirup weighs 577½ grains; a gallon weighs 13½ pounds; its specific gravity is 1·319 to 1·321, or 35° Baumé; its boiling point is 221° F., and its density at the temperature of 212° is 1·260 to 1·261, or 30° Baumé. The sirups prepared with the juices of fruits mark about two or three degrees more on Baumé scale than the other sirups. According to Ure, the decimal part of the number denoting the specific gravity of a sirup multiplied by twenty-six gives very nearly the number of pounds of sugar it contains per gallon.

The preservation of sirups, as well as of all saccharine solutions, is best promoted by keeping them in a moderately cool, but not a very cold place. Let sirups be kept in vessels well closed, and in a situation where the temperature never rises above 55° F. They are kept better in small than in large vessels, as the longer a bottle lasts the more frequently will it be opened, and the sirup consequently exposed to the air. By bottling sirups while boiling hot, and immediately corking down and tying the bottles over with a bladder, perfectly air-tight, they may be preserved even at a summer heat for years, without fermenting or losing their transparency.

The candying of sirups may be prevented (unless the sirup be over-saturated with sugar) by the addition of acetic or citric acid, two or three drachms per gallon. Confectioners add a little cream of tartar to the sirup to prevent granulation. Sirup may be effectually prevented from fermenting by the addition of a little sulphite of potassa or lime; also by the use of salicylic acid in small quantities. Fermenting sirups may be immediately restored by exposing the vessel containing them to the temperature of boiling water. The addition of a little spirit is also good, say about ten per cent.

A solution of sugar prepared by dissolving two parts of double refined sugar in one of water, and boiling this a little, affords a sirup which neither ferments nor crystallizes.

The basis of most mineral water sirups is simple sirup, which is prepared by adding sixteen pounds finest white sugar and the whites of four eggs to one gallon of water; stir until all the sugar is dissolved; simmer over a gentle heat for two or three minutes, skim well, and strain through a fine flannel bag.

* From the *Chicago Confectioner.*

The best way to keep fruit sirups from fermenting is by bottling while hot, into suitable bottles or larger vessels, and to prevent access of air. This is the principle, and it may be carried out in various ways. For instance, fill the sirup while hot in quart bottles, previously warmed, and fill them almost full. Cover or cork the bottles temporarily until the sirup cools a little and contracts in volume; then, having heated a small quantity of the sirup, refill the bottles, cork them securely, and wax them.

A great variety of sirups are made by the addition of proper flavoring ingredients to simple sirup; but in other cases, especially when the juices of fruits are employed, the sirup is not first prepared and then flavored, but the processes go hand-in-hand. In such instances specific instructions will be given. It is always advisable, when fresh fruit can be obtained, to use it in preference to the essence. One general recipe, which answers for nearly all fresh fruit, is as follows: Use nothing but the very best fresh fruit, which must be freed from stocks, etc., and crushed with a wooden instrument (not metal); when well mashed, let it stand in a room of even temperature (about 68° F.) for four days, which will give sufficient time for fermentation to take place; press out the juice from the fruit and let it settle in a cool cellar for two days, after which five pounds of the clear juice is to be simmered with nine pounds of loaf sugar; while warm, strain through flannel. The color may be improved by a solution of some coloring agent.

It is advisable to add to the fresh fruit before setting it for fermentation about two pounds of powdered loaf sugar for every hundred pounds of fruit. When cold it is ready for bottling. Cleanliness should be strictly observed in all the utensils used. When bottling for storing, skim the top of any floating matter from the sirups in the large pan, and see that no residue at the bottom goes into the bottles. Most of the sirups not made of fruit may have a little mucilage of gum arabic added, in order to produce a rich froth. The following recipes comprise sirups made from the fruit, and also from essences. These may be varied to suit taste and requirements. A variety of sirups have been brought into use by adding the various wines, such as claret, hock, sherry, etc., to simple sirup; others, by the addition of spirits, as milk punch, by adding to vanilla cream Jamaica rum and nutmeg. Almost any sirup may be made by the addition of a sufficient quantity of flavoring essence to simple sirup; but these artificially prepared sirups are inferior to those made from fresh fruits.

Red Coloring for Soda Water Sirups.—The most convenient is probably tincture of cudbear, as it affords a good, substantial, and natural-looking color, miscible with sirups without cloudiness. It may be made as follows:—3 to 4 ounces powdered cudbear, 1 pint diluted alcohol. Exhaust by maceration or displacement. Used alone, the tincture gives a shade of red closely imitating the color of raspberries or currants. For deeper red, like blackberries, the addition of some caramel is all that is necessary. The strawberry color is best imitated with tincture of cochineal. *Aniline red*, owing to its cheapness, is often used for coloring sirups, but it produces a glaring, artificial-looking, bluish-red, and is liable to the objection that it sometimes contains arsenic.

Ambrosia Sirup.—A mixture of equal parts of vanilla and strawberry sirups.

Apple Sirup.—Proceed with apples as for pine-apple sirups.

Banana Sirup.—Proceed with bananas as for pine-apple sirups.

Blackberry Sirup.—Prepared from ripe fruit the same as raspberry sirups. Blackberry sirup is improved by adding 1 ounce best French brandy to each quart.

Capillaire Sirup.—Nine pounds loaf sugar, 5 pounds orange flower water. Boil till the sugar is dissolved and the sirup is clear; while hot, strain through flannel; add to the cool sirup 2 drachms of tartaric acid, previously dissolved in 8 ounces of the strongest orange-flower water; lastly add 4 ounces of the best Rhine wine.

Cream Sirup (2).—One pint condensed milk. One pint water. One and one-quarter pound sugar. Heat to boiling and strain. This will keep for over a week in a cool place.

Cream Sirup—Imitation.—Make an emulsion with 3 ounces fresh oil of sweet almonds, 2 ounces powdered gum arabic, and 2 ounces water; then dissolve 1 pound white sugar by gentle heat, strain, and when cool, add the whites of two eggs. It should be put up in small bottles, well corked, in a cool place. This is not only an excellent imitation and substitute for cream sirup, but will keep for a considerable time.

Currant Sirup (1).—Six pints simple sirup. Two pints water. Two ounces tartaric acid. Three drachms fruit essence. Mix; color with liquid carmine for red currants, and with burnt sugar for black.

Currant Sirup (2).—One pint red currant juice. One gallon simple sirup.

Grape Sirup.—One half pint brandy. One ounce tincture of lemon. One gallon simple sirup. Tincture red saunders, 1 quart.

Ginger Sirup.—Six pints simple sirup. Two pints water. One ounce tartaric acid. Two ounces ginger. Burnt sugar to color.

Ginger Sirup (2).—Four ounces extract Jamaica ginger. One gallon sirup. Shake well. A few drops of tincture curcuma to color.

Ginger Sirup (3).—Nine pounds loaf sugar. Five pounds water. Twelve ounces essence ginger. Four ounces Rhine wine. Boil sugar and water until dissolved and clear; when cool, add ginger and wine. Mix well and let settle.

Imperial Sirup.—Equal parts of raspberry and orange sirups.

Lemon Sirup.—Grate off the yellow rinds of lemons, and beat it up with a sufficient quantity of granulated sugar; express the lemon juice; add to each pint of juice 1 pint of water, 3½ pounds granulated sugar, including that rubbed up with the rind; warm until the sugar is dissolved, and strain. Under no circumstances must the sirup be allowed to boil, and the less heat that can be used to effect the complete solution of the sugar the better will be the sirup.

Lemon Sirup (2).—Add to 1 gallon simple sirup, when cold, 20 drops fresh oil lemon and ¼ ounce citric acid, previously dissolved in 3 ounces water; mix by shaking well in a bottle; add 4 ounces gum solution, made by dissolving 2 ounces of fine white gum arabic in 2 ounces warm water.

Lemon Sirup (3).—Six pints simple sirup. Two pints distilled water. Two ounces essence lemon. Two ounces citric acid, dissolved in boiling water. Mix, and, if required, color with saffron.

Maple Sirup.—Three and one-half pounds maple sugar. One quart water. Dissolve, and, if desired, add a small proportion of gum solution to produce a rich froth.

Milk Punch Sirup.—To 1 pint heavy sirup add one-half pint each of brandy and Jamaica rum; flavor with two tea-

spoonfuls of an extract, prepared by macerating 2 ounces of ground nutmegs in 8 ounces of alcohol. The sirup is first to be poured into the glass in the proper quantity, and ordinary cream sirup added before drawing the soda water.

Mulberry Sirup.—Made from the fruit, the same as strawberry, and acidulated slightly with a solution of citric acid. It may also be made from the fruit essence in the same manner as for strawberry, using about half the quantity of tartaric acid.

Nectar Sirup (1).—One ounce extract vanilla. One ounce extract rose. One ounce extract lemon. One ounce extract bitter almonds. Mix and add 1 gallon simple sirup; color pink with cochineal.

Nectar Sirup (2).—Mix 3 parts vanilla sirup with 1 each of pineapple and lemon sirups.

Orange Sirups.—These may be made from the fresh fruit or from the essence in a similar manner as for lemon sirups. Orange sirups may be colored slightly with tincture of saffron or of turmeric.

Orgeat Sirup (1).—One half pint of cream sirup. One half pint simple sirup. One pint vanilla sirup. Five drops oil bitter almonds.

Orgeat Sirup (2).—Beat to an emulsion in a mortar 8 ounces blanched sweet almonds and 4 ounces bitter ones, adding a little water; when smooth add 3 pints water; mix and strain; dissolve in this without heat 6 pounds sifted white sugar, and 4 ounces fresh orange-flower water.

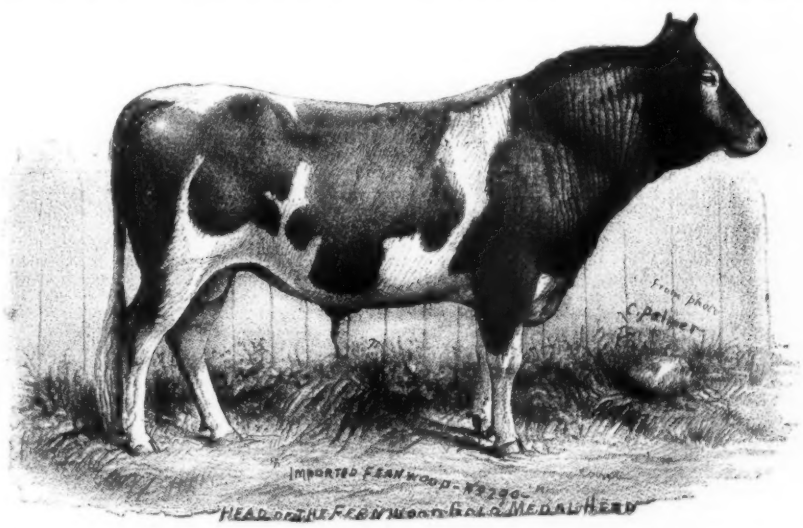
An excellent imitation of orgeat sirup is made by flavoring cream sirup, made with eggs and milk, with a few drops of oil of bitter almonds.

Pear Sirup.—Proceed for pears as for pineapple sirups.

Pineapple Sirup (1).—Take a convenient number of the fruit; pare and mash them in a marble or porcelain mortar, with a small quantity of sugar; express the juice; for each quart of juice take 1½ pints of water and 6 pounds of sugar; boil the sugar and water, and add the juice; remove from the fire; skim and strain.

Pineapple Sirup (2).—Six pints simple sirup. Two pints distilled water. One ounce tartaric acid. One drachm essence pineapple. Saffron to color.

Pineapple Sirup (3).—Proceed as for raspberry (4); but the hard nature of this fruit requires pounding with a heavy chump of wood (not metal) in a tub with a strong bottom; when well mashed it will require great pressure to extract all the juice from this fruit; a cider press will answer the purpose; add 14 pounds of sugar to a gallon of juice and a little pure acetic acid; put it on a slow fire, and stir until the sugar dissolves; when cold, bottle and tie down.



Raspberry Sirup (1).—Take fresh berries and inclose them in a coarse bag; press out the juice, and to each quart add 6 pounds white sugar and 1 pint of water; dissolve, raising it to the boiling point; strain; bottle and cork hot, and keep in a cool place. Raspberry sirup is improved by adding 1 part of currants to 4 parts of raspberries.

Raspberry Sirup (2).—Five quarts raspberries. Twelve pounds white sugar. One pint water. Sprinkle some of the sugar over the fruit in layers, allowing the whole to stand for several hours; express the juice and strain, washing out the pulp with the water; add the remainder of the sugar and water; bring the fluid to the boiling point, and then strain. This will keep for a long time.

Raspberry Sirup (3).—Six pints simple sirup, 2 pints water, 2 ounces tartaric acid. 2 ounces essence raspberry. Coloring sufficient. Coloring for raspberry, blackberry, etc., sirups may be made by boiling 1 ounce cochineal with half a teaspoonful cream of tartar; filter.

Raspberry Sirup (4).—Take any quantity of fully ripe fruit; free them from stalks; place them in a tub and crush them with a wooden spatula; after they have been mashed, let them remain for three or four hours, and strain the crushed berries through a strong flannel bag or strainer into a suitable vessel. Dissolve ½ ounce citric acid in 3 ounces water, and add this quantity to each gallon of juice; mix 14 pounds of broken sugar to every gallon of juice; put on a slow fire and stir until all the sugar is dissolved (not boil); take off the fire, and when cold, bottle and cork for future use. If too thick when cold, it may be brought to a proper consistency by the addition of water.

Raspberry Sirup.—Imitation.—Three ounces bruised orris root. Two ounces acetic acid. One ounce acetic ether. One pint of alcohol. Cochineal to color. Mix and allow to stand a few days; filter, and use to flavor simple sirup.

Rose Sirup.—One gallon simple sirup, 1 ounce essence rose. Color pink with prepared cochineal, and acidulate lightly with a solution of citric acid.

Sarsaparilla Sirup (1).—One gallon simple sirup. Two ounces essence sarsaparilla. Color with caramel.

Sarsaparilla Sirup (2).—One gallon simple sirup. Essence sarsaparilla q s. One ounce powdered extract licorice. Fifteen drops oil of sassafras. Fifteen drops oil of wintergreen. Ten drops oil of anise seed. Stir the oils with the powdered licorice; add a portion of the sirup; stir smoothly, and mix the whole together by agitation.

Sherbet Sirup.—Mix equal parts of orange, pineapple, and vanilla sirups.

Sherry Cobbler Sirup.—To 1 pint good sherry add an equal measure of heavy simple sirup, and one lemon cut in very thin slices. Allow the sirup to stand a few hours; strain through a sieve, and bottle for use.

Strawberry Sirup (2).—Proceed as for Raspberry Sirup 4; but the fruit being more stubborn will require a good beating with the spatula to mash them; when they have stood three or four hours strain and press the juice out by squeezing the strainer between the hands; add to the juice the same quantity of citric acid; dissolve in each gallon 14 pounds of loaf sugar; simply warm the juice sufficiently to dissolve the sugar; take from the fire, and when cold, bottle and cork till required.

Vanilla Sirup (1).—One gallon simple sirup. One ounce extract vanilla. One-half ounce citric acid. Stir the acid with a portion of the sirup; add the extract of vanilla; mix.

Vanilla Sirup (2).—Four pints simple sirup. Two ounces extract of vanilla.

[In the SCIENTIFIC AMERICAN SUPPLEMENT, No. 77, will be found another series of fifty recipes for sirups, which will be found valuable in connection with the foregoing].

THE MANUFACTURE OF CEMENT AT FOLKESTONE.

IN the new harbor works of the Southeastern Railway Company, now in course of execution at Folkestone, artificial blocks, made of pebbles from the sea beach, bound together with Portland cement, are largely used. The Portland cement is obtained from the Folkestone Cement Works, about half a mile from the harbor; and at the cement works the raw materials are obtained close at hand. The works stand upon an inclined plane; chalk is brought to them from the cliffs above, and clay is wound up to them by a stationary engine from a clay-pit a hundred or two yards from the place of manipulation. A correspondent of the *Engineer*, who recently visited the works, sends us the following:

The Folkestone Cement Works were established and carried on for two or three years as a private speculation; in 1873 they were bought up by a company consisting chiefly of residents in the neighborhood; at the present time Mr. John Minter, solicitor, is the chairman of the company; Mr. J. B. Judge, secretary, and Mr. Charles Spackman, manager.

The materials for the manufacturer of Portland cement vary in different districts. On the Thames, white chalk and alluvial mud found in the marshes adjoining the Medway are used; on the Medway, gray chalk and the same mud; in the Lias districts, the limestone shales and clays of the deposits furnish the most suitable materials. At Folkestone gray chalk and the gault clay which underlies the gray chalk, as already stated, are the raw materials.

At Folkestone the different beds of both substances vary considerably in composition. When free from water the chalk contains from 84 to 95 per cent. of carbonate of lime, the rest being clay, and the clay, in a dry condition, contains from 10 to 30 per cent. of carbonate of lime. The chalk upon an average contains 20 per cent. of water, the clay 25 per cent. The first object to be attained is to reduce the substances to a fine state of division, and at the same time intimately mix them together in such proportions that when deprived of water the mixture shall contain from 75 to 76 per cent. of carbonate of lime. This is done by what is known as the wet process. The raw materials are fed in measured proportions into a wash-mill, which is a circular trough in which a number of harrows revolve, driven by a steam engine of 14-horse power. A stream of water is constantly flowing in, and the action of the harrows, aided by the attrition of the particles against each other, reduces the whole to the state of "slurry" or slip, which contains from 60 to 70 per cent. of water; in this state it flows into the settling tanks or "backs," each of which contains sufficient slurry to make 800 tons of cement. Here it is allowed to subside, the supernatant water being drawn off from time to time. One settling tank is filled at a time, and then left for six or seven weeks for the solid matter to settle, the surface water meanwhile being drawn off from time to time by a small sluice. The bottoms of the tanks are of the natural porous earth of the locality, and help a little to drain off the water by absorption.

To return to the wash-mill. No coarse particles of chalk must be allowed to pass into the backs, as their presence would endanger the cement. To guard against this the slurry is caused to flow away from the wash-mill through strainers of fine copper wire gauze. Catch-pits are placed between the strainers and the backs to intercept any coarse particles that may have escaped. The process is a continuous one, a stream of water with successive charges of chalk and clay constantly going in, and a stream of slurry continually flowing out. The rate of flow has to be carefully regulated, so as to secure a proper mixture. Some of the beds of clay are easily washed down, while others are most tenacious and difficult to break up. Some of the chalk is soft and is easily washed; other beds, notably that called the "burr chalk"—which is a kind of junction bed between the upper and lower chalk deposits—are harsh and gritty in the breaking up. The mechanical condition of the slurry is continually examined during the process of washing, by washing a small known quantity through a fine sieve, and drying and weighing the residue. The composition of the raw materials being known, their accurate mixture in the required proportion is simply a matter of calculation. To guard, however, against possible error, the percentage of carbonate of lime in the slurry is constantly determined. If the percentage is not correct the proportions are altered, while occasional stirring of the backs insures a uniform product. Many methods of analysis are adopted. The lime may be determined directly, but the operation involves much time and tedious work, especially where as in a cement works many determinations have to be made. For all practical purposes a determination of carbonic acid in a dried and gently ignited sample of the slurry is sufficient. From this the percentage of carbonate of lime can be readily calculated. A form of apparatus which will give the required result in from fifteen to twenty minutes, and involves only one weighing, viz., that of the quantity taken for the determination, is that of Dr. Scheibler. The carbonic acid is collected over water, its volume read off, and the weight calculated with the usual corrections for temperature and atmospheric pressure. Another method, which is very accurate, is to absorb the carbonic acid in a U tube filled with potash, pumice, or soda lime, the tube being weighed before and after the operation. There are several forms of apparatus by which carbonic acid is determined as loss, that known as Parnell's being one of the most useful. When sufficiently stiff to be dug out, the slurry, still containing from 40 to 50 per cent. water, is removed from the backs in wagons to the drying floor. This is heated by the waste gases from a range of coke ovens, in which just sufficient coal is coked to dry sufficient slurry in twenty-four hours to load one kiln. The kilns are seven in number, from each of which eighteen tons of cement clinker are drawn. The process of burning is an intermittent one. The kiln is charged with alternate layers of coke and dry slurry, lit at the bottom by means of thirty baskets of coke laid upon brushwood fagots. These kilns are subject to great wear-and-tear, which are materially lessened by coating their sides with slurry before each charging. A charge is usually burnt off in thirty-six hours, after which it is allowed one or two days to cool. The charge is then drawn. The fuel and slurry are distributed in the kiln according to the judgment of the burner. At these works one ton of cement is burnt with twenty bushels of coke.

It may be mentioned here that slurry prepared with a somewhat lower percentage of carbonate of lime than that previously mentioned, say from 72 to 73 per cent., would require less fuel to burn it, and the resulting clinker would be more easily ground, but the cement would have a low tensile strength. On the other hand, a higher percentage would largely increase the quantity of fuel required, give a dense hard clinker very difficult to grind, and the cement would be liable to crack and fly when used. The product from the kilns is a hard blue-gray clinker, from which all underburnt portions are carefully picked out. The clinker is crushed by one of Hall's multiple action stonebreakers, taken by an elevator to a chamber above the mill, from whence it descends to the millstones. After being finely ground it is spread out in the warehouse for a few days, when it is packed in casks or sacks for delivery.

Portland cement is usually tested as to its tensile strength, and every English engineer who buys it applies his own tests, instead of adopting one general and fixed rule as in Germany. At Folkestone the manager tests what strain the cement will bear after being kept for seven days under water. The test demanded by Mr. Brady at the Folkestone new harbor works is that it shall bear a strain of 810 pounds on a sectional area of 2¼ square inches seven days after moulding.

During the process of grinding samples are continually taken for the purpose of being tested. Mr. Spackman informs us that during the year 1881, the average of the tests gave a tensile strength of 497 pounds on the square inch of sectional area.

The total output of Portland cement at the Folkestone works is 120 tons per week.

Analysis of a Sample of Slurry taken from the Backs in April, 1882.

The slurry dried at 100° C. contained: Insoluble in hydrochloric acid:

Silica	14·956	
Ferric oxide	1·943	
Alumina	5·167	
Lime	0·173	
Water of combination and organic matter	1·203	
		23·442
Soluble in hydrochloric acid:		
Silica	0·230	
Ferric oxide	0·493	
Alumina	0·230	
Carbonate of lime	75·357	
Magnesia	0·201	
Sulphuric anhydride	0·057	
Potash	0·070	
Soda	0·127	
		76·765
		100·207

Analysis of some Samples of Portland Cement.

No. 1. The Folkestone Cement Company's, March, 1880.

No. 2. The Folkestone Cement Company's, September, 1881.

No. 3. From a works on the Thames, 1881.

No. 4. A sample which possessed a strength of 500 pounds on a square inch, made from a mixture of blue lias limestones.

No. 5 is especially interesting. The cement was made by Mr. Spackman from refuse from the Channel tunnel boring at the end of 1881, and possessed a high tensile strength.

	1.	2.	3.	4.	5.
Insoluble residue	1·260	2·566	2·894	4·909	1·674
Silica	20·990	18·917	21·307	18·583	23·832
Alumina	8·869	8·763	6·593	7·226	6·058
Ferric oxide	4·998	4·412	5·386	5·108	3·127
Lime	61·351	62·472	61·459	61·040	63·129
Magnesia	0·669	0·841	0·449	1·565	1·206
Sulphuric anhydride	0·886	0·929	1·423	0·763	0·398
Potash	0·978	1·100	0.437	0·754	....
Soda	....	....	0·429	0·271	....
	100·000	100·000	100·376	100·219	99·424

[Continued from SUPPLEMENT 349, page 5566.]

THE PANAMA CANAL.

By MANUEL EISSLER, M.E., of San Francisco, Cal.

VI.

THE GEOLOGY AND PETROGRAPHY OF THE ISTHMUS.

BESIDE the facts which I have been able to gather, some very valuable notes were furnished to me on the geology of the isthmus, as far as the same relates to the line of the canal, from memoranda of Mr. M. E. Boutan.

He is an eminent French geologist, who was sent out last year by the Paris Congress to make the classification of the rocks through which the canal has to pass, especially keeping in view their hardness.

Naturally such a study was almost an impossibility there, as the vegetation and soil covers the rocks, but still, incomplete as the data are which I am compiling here, they will be a guidance for further developments, as the actual work will bring daily new facts to light.

I collected a great many samples, and those in which I could see distinguishing features from one another, I presented to the State Mineralogical Cabinet of California, in this city (212 Sutter street), where our State Mineralogist, Professor H. C. Hanks, has assigned them an appropriate place.

COLON.

Aspinwall, at the head of the line, is built on the small Island of Manzanilla, formed by madreporic reefs, covered with a muddy clay and a vegetable earth of little fertility (impregnated with salt water), and which cannot produce a luxuriant vegetation, and only mangroves and manchineel trees with some cactuses grow there.

The abundant corals there all belong to living species, and form, so to say, the skeleton of that island.

After crossing the small arm of the sea which separates this island from the mainland, and pass the low and marshy shores, we come to Monkey Hill (Loma del Mono), the foothills of the Sierra Quebrancha, which is formed for a certain depth of a very fat clay, somewhat fossiliferous, colored red by the presence of oxide of iron, and which clay seems to cover the older formations on a great many other points of the isthmus on the Atlantic and Pacific side. The same resembles very much our red soil (in appearance) in Placer, Nevada, and counties through which the Central Pacific Railroad runs.

This red clay is to be noticed even in the width of the marshes of Mindi, also along the line of the Sierra Quebrancha, whose foothills reach as far as Gatun.

Under this clay, which is of variable thickness, we observe, according to locality, different formations.

In the vicinity of Monkey Hill there is a sort of tufa of grayish color, a sort of calcareous clay, composed of fossil shells of all sizes down to microscopical dimensions, which seem to belong to the most recent tertiary layers, and they contain here and there, in the body of their mass, round pebbles or rather kidneys, which are harder and of finer grain, but of an analogous composition. The same formation is met with 3 kilometers further on, on the other side of the marshes.

At Gatun, where the raiload quits the last hillocks by which the Sierra Quebraucha loses itself at the banks of the Chagres, the red clay reposes on the contrary on a deposit of a certain soft rock, which is very interesting on account of its structure.

This rock is composed of rounded grains of different sizes, sometimes as large as hazelnuts, which have a very fine constitution, and which are again embedded in a coarse paste, colored red by oxide of iron.

These grains are grayish, sometimes turning to greenish and violet colors. It is a sort of conglomerate, formed of the elements of all the trachytic rocks which we meet later on, and which have been submitted to decomposing influences.

Dr. Wagner, who has paid particular attention to this conglomerate, says that they do not contain the elements of the doleritic rocks, and that they come from an earlier geological epoch.

I have noticed similar conglomerates at the railroad cuts near Gatun.

Near Gatun, on the left bank of the Chagres, is the little hill Miraflores. It stands there isolated, commanding the river, and served in former centuries as a stronghold defending the passage of the river, but of the forts established there hardly any vestige remains.

This hill is formed, at its base, of a sandy, friable rock, whose elements are composed of quartz, feldspath, and hornblende, with a little oxide of iron, and seems to be of the same nature as Monkey Hill, but being nearer to its original point of derivation, it is composed of coarser grains. This formation is visible for a thickness of 5 to 6 meters, and covered by a sort of trachytic tufa, of which the different layers seem to be identic to the tufa formations of Barbacoas, which we encounter later on.

The rocks of Tiger Hill (Loma del Tigre), the last foot hill on the Atlantic side of a magnificent mountain chain, which joins, in the upper valleys of the Pequeñi, the Sierra of Santa Clara, are formed of species of crystalline trachytic rocks, hard, rough to the touch, containing numerous fragments of shells and corals, and mixed especially with orbitoides. All the elements of the trachytic rock indige nous to the country can be noticed there, and the microscope confirms this observation by showing fragments of volcanic rocks, with numerous crystals of feldspath, labrador, hornblende, and quartz. In all the railroad cuts between Tiger and Lion Hill, this same rock, sometimes of a finer, sometimes of a coarser texture, is observable, but always of the same composition.

On leaving the station of Lion Hill, in following the railroad track, the same falls again into the swamps (Miller's swamps) for a length of 4 kilometers. (I will observe here that to get an idea of the geological features the railroad cuttings, river banks, soundings, and shafts offer the only means of study.)

After passing the hamlet of Ahorca Lagarto and the rivulet Juan Gallegos, we encounter, to the right, a series of little hills (not laid out on the map).

These hills are formed of a whitish limestone, grained, crystalline, crossed with veins of spath, in which the microscope detects the existence of feldspath, globular limestone, and large quantities of corals, rhizopods, or foraminifers, which are all mostly microscopic species and resemble the nummulites.

This limestone, which we find again a little further on, at the foot of the Sierra of Buhio Soldado, does not appear on the left bank of the Chagres, where are only found, in the bend which the river makes below Vamos Vamos, layers of sandstone, or rather agglutinated sand, whose color varies from red to greenish black, and which sand is the derivation of the decomposition and disintegration of the doleritic and trachytic rocks of the great mountain which crowns the Cerros Gigante. This limestone formation, nevertheless, may acquire a great importance, both from a practical and theoretical point of view, as not only in the execution of certain works on the canal it will prove of utility, but also this formation may give indications which may lead scientists to determine the exact period of the upheaval of the isthmus.

Napoleon Garella speaks of this limestone formation in his valuable manuscript as follows:

"Below Vamos Vamos, between that point and the Estero Juan Gallegua, on the right bank, I found rocks of calcareous sandstones and grained limestone, in banks several meters thick, having a S. E. and N. W. direction, dipping 20° S. W. To these limestone layers are associated layers of a fine, grayish sandstone, in which I noticed disseminated particles of crystalline limestone. One and the other of these rocks, especially the first, appear to me can be used as a building stone. As to their geological age, the small extent exposed, the impossibility to know their direct relations with the other ground, render their exact determination very difficult; nevertheless, their mineralogical character, their association, and their intermediary position between the tertiary rocks of the Chagres and the older rocks of the central mountain masses, lead me to the conclusion that they belong to the middle of the secondary epoch."

This characteristic formation makes soon room to new apparitions: of sands first, then of gravel, held together by a calcareous cement, containing, like those of Vamos Vamos or at Gatun, all the elements of the generating rocks of the isthmus, arranged in a certain degree in size as we advance more and more. These gravels give place, a short distance before reaching the station of Buhio Soldado, to conglomerates, made up of large blocks of the fundatory rocks of the isthmus, in which can be clearly distinguished the two fundamental types of the crystalline rocks.

The first, of a gray color, drawing to yellow, probably in consequence of a posterior decomposition, is formed of an amorphous paste, with microlites of oligoclase, containing, besides some quartz, crystals of feldspath, hornblende, labrador, and iron oxide.

The second is heavier, of a dark greenish color, and differs essentially from the first by its crystalline paste of microlites of labrador and its coarser elements.

It contains, besides, more pyroxine (Augite), less feldspath, and no hornblende. It is impossible to recognize the passage from one to the other of these varieties of conglomerates, which are found successively in almost all the cuts of the line as far as Buena Vista. The samples found do not differ much from the preceding ones; they appear to belong to the hornblendic series, also contain some mica, and frequently particles of opal and chalcedony can be noticed in them.

This series of conglomerates is cut at the station of Buhio Soldado by an important formation, entirely different from those which surround it, and which rock is at present taken out by the railroad company, who have opened a big quarry there, and is used by them in their construction works, like for bridge piers, abutments, etc., etc., and this formation has in this manner been laid open for a height of 15 meters.

Taken as a mass, the rock which composes it is entirely homogeneous for its entire height (as laid bare), without any stratification or cleavage, sufficiently soft to be worked easily and also to be blasted out, but still sufficiently hard to offer enough resistance to the stonecutter in shaping it, and is also compact enough not to break up and decompose through atmospheric agencies, and the railroad people told me that for their purposes it answers very well, and no doubt the canal company will have plenty of use for it also.

From a mineralogical standpoint, this is a true volcanic rock, formed of angular and rounded nodules, embedded in a crystalline pyroxenic matrix of labrador and oxide of iron, which latter two elements are cemented together by opal, as well as by a greenish fibrous or concrete matter, whose nature is not exactly understood.

This peculiar constitution manifests itself in working the stone with the chisel, as the harder nodules sometimes prevent its easy cutting, whereas again in the softer paste the same naturally penetrates with greater facility.

This same rock is not met with in any other locality.

This rock differs entirely as far as appearance goes from the trachyte-dolerites, which form the elements of the different conglomerates, but the Buhio Soldado formation seems to be, on the contrary, a true volcanic mud, which has solidified and remained in an amorphous condition in spite that the same contains a large number of small crystals, of which some are visible to the naked eye, but the majority have to be detected through the microscope.

On arriving at Buena Vista those red clays are found again. They appear here as before on the surface of the earth, and repose on a conglomerate very similar to that at Gatun. On leaving Buena Vista we enter the alluvial plains which are cut through by the rios Agua Salud, Frijolito, and Frijole; 10 kilometers further we find this red clay again, that is at Tabernilla, where we notice it for a distance of 3 kilometers, to within a short distance of the bridge of Barbacoas, covering in that space a sort of decomposed trachytic tufa, analogous to the trachytes which we find in immense masses at the abutment of the bridge over the Chagres, but which rock is in this locality in a non-decomposed condition.

This is one of the interesting points along the line, as it is about the only place where the formation, from 15 to 20 meters high, has been exposed to view, and rising vertically on the right bank of the Chagres, it made a natural abutment for the iron bridge.

It is a sort of white trachytic tufa, coarse to the touch, forming layers of a banded structure, forming a confused stratification, in which nevertheless the general direction can be ascertained—N. 30° E., with a dip of 18° to 20° to the N. W. Some of the different banks which are seen are of a coarse grain, others again are of a finer constitution and more compact. The amorphous mass, generally feldspathic, but mixed sometimes with some limestone, contain some small crystals of oligoclase, and presents the appearance of an obsidian somewhat devitrified.

This rock Garella calls, in his memoranda, sandstone grit or gray rock of transition, but it is rather an ashy tufa, having little consistency, often fissured, very uneven as to hardness and grain, and can in no manner serve to indicate on its surface as to its constitution.

This cannot be said of a rock which is found after passing the river, and which is met with over a large extent of country in the neighborhood of San Pablo station. This formation is seen on the left banks of the Chagres; where the same is noticed on several points, but to the best advantage along the railroad track, where this rock was quarried out formerly and exposed for a height of 7 to 8 meters, but since the discovery of the quarry of Buhio Soldado, which gave a material resisting better to atmospheric influences, this one has been abandoned.

This tufa is entirely different from the one at Barbacoas; this is rather a trachytic breccia, yellowish and more crystalline, covered with green spots, and, contrary to the preceding formation, is a product of decomposition and disintegration.

Taken as a mass, it seems to present a compact form, without a trace of an apparent stratification, although Messrs. Wyse and Reclus, in their observations, seem to think that the layers are dipping 16° to the north. Under the microscope they exhibit some crystals of pyroxene and labrador, very much decomposed, with a rare cement of chalcedony.

Between San Pablo and Matachin the valley gets narrower and the river makes numerous bends, running in a bed of alluviums, but showing the formation of the bottom slopes of the hills sometimes, but here, as well as in the railroad cuts, we find on this section an uninterrupted succession of trachytic and doleritic conglomerates, cut through here and there by the alluviums of the affluents of the Chagres, like the Baila Monos, Caravali, on the left bank, the Pisco and Juan Grande, on the right shore.

Sometimes these conglomerates are cemented by a hard paste, of an entirely analogous nature to the bowlders and pebbles forming this conglomerated mass, and can hardly be distinguished from them, and at other times this conglomerate is entirely decomposed and looks like pulverulent sand, and to this mass the aspect of immense alluviums is given, which seem to be produced at the expense of the neighboring hills.

As to the bowlders themselves, they are sometimes like, between San Pablo and Baila Monos, a certain species of gray and violet colored trachytes, formed principally of crystals of feldspath, grains of quartz, mica, hornblende, sometimes, but on rarer occasions, and of smaller quantities, of pyroxene; at other times, on the contrary, like between Baila Monos and Mamei, they are darker, belonging to the trachyte dolerites, and formed of a labradoric and pyroxenic paste, with large crystals of pyroxene and numerous grains of oxidulated iron. The first species seems more especially to constitute the left bank of Baila Monos, the other the right bank.

But these bowlders decompose also and give earthy products of a whitish color and also of a green-brownish color. These are noticeable in front of Mamei, where in one of the cuts they resemble large balls of clay, of a globular, concentric structure, which formation results from the superficial decomposition due to humidity and general atmospheric agencies.

The alternations in the formations are different after passing Mamei. On leaving this station, we see a cut made in a whitish trachytic conglomerate very much decomposed and very soft, to which soon succeed conglomerates with large doleritic elements, held together by a brown clay or sands, which are sometimes without consistence; at other times they are strongly cemented together; but as soon as we have passed the Cerros Uraba and Culeseco, we find clays of variegated red and gray colors, which seem to be decomposed tufas, colored by oxide of iron, and which differ entirely from the red clays, fine and more uniform in color, of Tabernilla and Gatun.

These clays disappear and re-enter an alluvial plain, which extends between La Gorgona and Matachin, where even small mounds are formed by these alluviums, excepting at a point where a cut allows us to perceive again the reappearance of the doleritic conglomerates, and in which the bowlders, when decomposed, are made up of concentric layers which will scale off successively in very decided layers.

Mr. Boutan, in speaking of this formation, says:

"I do not think that much importance ought to be attached to the presence of the clays which I have determined in the vicinity of La Gorgona; I believe to be able to say that below the alluviums are more or less thick, and more or less wide of the Chagres, which extend on each side of its bed and to variable distances; the terrain is composed of conglomerates which are trachytic or doleritic, but its laws of succession or alternations I could not clearly define on account of the insufficient observations; but their hardness, depending from their state of decomposition, ought to be considerable in depth.

"I think a find a proof of this assertion in following the bed of the river, and examining carefully the banks where the rocks have broken through to light."

(In some of the soundings along this section the decomposition has reached quite a depth, and the hardness of the underlying rock is not so great as anticipated.)

At Matachin, the second section of the canal commences and the tracé enters a more hilly country, and consequently more difficult than the preceding section; but, before undertaking the description and abandoning the lower valley of the Chagres, it is necessary to make a short digression to the upper part of this valley, as well as to the locality where the great dam will be located.

It is well known to the reader that at Matachin the Chagres makes the big bend and runs in a N. N. E. and S. S. W. direction.

About midway between Matachin and Cruces, the valley gets narrower and finds itself contracted between two hills, the Cerro Gamboa on the left bank, and the Cerro Baruco, a foothill of the Cerro Pelado, on the right bank. This contraction, beyond which the valley assumes again its natural width, is still very wide, and the dam, which will be 40 meters high, will not have less than 1,600 meters length. It would have been very desirable to have another locality for the establishment of the dam, as it will be a very costly piece of work; but in ascending the Chagres, the next and nearest contraction of the valley is found at La Campana, about a day and a half's journey up the river in pirogues, but in establishing a dam there the capacity of the reservoir created would have been insufficient, and also, it would have left the lower portions of the valley (below La Campano) exposed to the inundations of the Rio Chilibri, an affluent of the Chagres above Cruces, which might become dangerous to the canal.

Although the point chosen for the dam is admitted to be disadvantageous, not alone on account of the width of the valley, but also on account of the depth of the alluviums in which the Chagres runs, and consequently the increased expense to give the dam a solid basis, it became nevertheless an imperative necessity to adopt this locality.

Mr. Boutan in speaking of this locality says:

"On the left bank, the Cerro Gamboa, whose constitution is nearly identical to the central divide, is composed of doleritic breccia analogous to another remarkable breccia which I noticed further on on the slopes of the Cordilleras; but which is here more decomposed, at least on the surface; its fragments, all of a volcanic origin, are greenish or violet colored, and take the aspect of a compact feldspath (petro-

silex, der feldstein); the paste is chalcedony and opalescent."

After leaving the station of Gamboa, on the banks of the river, and in climbing up the slope of the hill, there are met with points of black rock sticking out, which are very hard, lustrous, with a shining fracture, giving sparks under the steel, and in which the microscope shows an amorphous dark paste, in the body of which are discovered grayish specks, which depolarize vaguely the light and seem to be oligoclase, and also small crystals of an indistinct form, which depolarize the light energetically and seem to be pyroxene.

These are kinds of veins, whose croppings stick out above ground on account of their hardness, and which rock does not seem to be so sensible to the superficial decomposition from atmospheric agencies.

On the right bank, on the contrary, the rocks which are met with on Barucco Hill, are principally large blocks scattered all over the surface and formed of trachytic tufas, of a yellowish color drawing to violet, sometimes of a fine, at other times of a coarser grain, much lighter to the preceding rock, and belonging to the hornblendic series.

The nature of the rocks on which the sides of the dam will repose will offer on both sides a very solid basis, but their character is different, and it was impossible to determine their line of contact. Aside from the ordinary difficulties, one is stopped in his examinations by the heavy alluviums in the bed of the Chagres, and in which the soundings had not found the rocky bottom yet. (Later advices are to the effect that the solid rock has been found in the bed of the Chagres at the emplacement of the dam, at a depth of 27·10 meters.)

Mr. Boutan, as well as some of the former explorers, are under the impression that no granite exists on the isthmus; as far as the line of the canal and its immediate vicinity is concerned they are correct. Mr. Boutan says:

"At Cruces, in the alluviums I have gathered a certain number of pebbles, which I think gave me some idea of the formation of the upper part of the valley. In the first place I did not find any granite here as in other places examined, although its presence is claimed on the isthmus, and especially in the rounded pebbles of the Chagres, where Dr. Wagner claims to have noticed them. (Dr. Wagner is right in this observation.)

"I have found but very little limestone. The kind I noticed, was hard, compact, heavy, of a dirty gray or yellowish color, formed of fossils which I could not determine. Other samples have been brought to me from La Campana, to which locality I had unfortunately no time to go, in which could be distinguished a large number of fossils of circular form or flat, which are probably orbitolites, but which cannot be placed among the nummulites.

"With the exception of these I have only found rocks of a volcanic nature, one kind with a paste of a green color, sometimes disseminated with iron pyrites, the other kind with a coarser paste of a dark green or violet color."

Mr. Boutan is perfectly right as to his observation regarding the absence of other rocks on the line of the trace, but as soon as we get to the east or west of that line, say nearly two miles, I will have occasion to notice an entire change of formation. I have gathered some pebbles on the beach of Matachin, which I mistook for limestone, but on breaking them open I was astonished to find they were jaspers; some of these were of a blood red color and others of different varieties, like striped jasper, which took a very fine polish, and which lets me draw the conclusion that at the upper portion of the Chagres various formations are met with, and these jaspers, which are quite abundant, have been produced through the igneous action on shale, which has been thereby changed to jasper. As the basalt or trachyte breaking through the more ancient rocks bring about some remarkable chemical and mechanical changes, I am rather in the dark to account for the light film of limestone which covers these jasper pebbles, and led me to mistake them till I broke them open accidentally. I am also told that on the upper Chagres some fine emeralds have been found.

At Gamboa one of the engineers found a large bowlder of rock, which proved to be porphyritic quartz impregnated with iron pyrites, and I detected under the lens numerous particles of gold, drawing the conclusion that higher up porphyritic formation with precious metal-bearing veins is to be found.

Beyond Matachin, the trace of the canal quits, as I have mentioned before, the valley of the Chagres, and enters into the Rio Obispo, and directs itself toward the Culebra Pass. In this second section the hard rocks will have to be attacked. As far as appearance goes, they are most darkly colored, greenish rocks, approaching nearly all the dolerites. In the first two kilometers we find hard conglomerates, somewhat decomposed on the surface, where the crystalline nodules always show the same labradoric paste, containing crystals of pyroxene and even orthoclase, with a large quantity of iron oxides, and the substance which surrounds them is of analogous elements, but composed of grains of different sizes strongly cemented.

These conglomerates are soon replaced by a very hard rock, giving fire with steel, in tabulary fragments, in which the naked eye cannot distinguish the elements. Under the microscope the same shows a formation of a grained pyroxenic paste, in which are numerous crystals of oligoclase and grains of iron oxides and oligiste iron ore, as well as nodules of quartz, amorphic on the outside and crystalline in the center.

But this rock seems to be rather sporadic, as the same is only seen again in a short railroad cut before arriving at the falls of the Obispo River, where the same makes soon room to a sort of porphyry, which can be examined here very thoroughly, as the same is forming the vertical walls of the high projections forming the falls.

This is also a very distinct formation, and this breccia, formed of red and green fragments, embedded in a greenish matrix, which becomes yellow by decomposition, has not the physical aspect of the crystalline rocks which we have met in the preceding sections. This one is cellular, rough to the touch, almost amorphic, and attracts the magnetic needle.

Under the microscope the fragments seem to be formed of oligoclase, whereas the paste shows a fluidale structure, formed of a pyroxenic ocher, iron oxides, and rounded grains of silica.

This same breccia is met with, first in a decomposed state and more quartzy on the railroad line, but the same cannot be seen there over such a large surface. Its color here is fresher, and covered with little cells, filled with a greenish pulverulent mass, which can be scratched out easily with the point of a knife, and also fine points of white crystals can be noticed in it, which appear to be feldspath.

A little further on, on the contrary, this rock is again more decomposed, although more quartzy, and rounded chalcedonic balls are found in it, which seem to establish a very clear transition between the preceding one and another breccia of an analogous nature found still further on, at the foot of the Cerro Pruja, on the road leading from the station of Emperador to a gold mine situated on the banks of the Rio Saldanillo.

There have to be signalized, between these points and the station of Emperador, species of tufas, clays, etc., completely amorphous, having either a homogeneous aspect, sometimes again of variegated colors, and containing in their mass rounded lumps or geodes of harder rocks, and the whole seems to be derived from the decomposition of the breccias, which make up the principal mass of the Obispo falls and bed.

Some distance before arriving at the station of Emperador, at the Lacar bridge, in a cut, a white limestone is found, compact, and only to be noticed at that point, and none is to be observed in that neighborhood. This limestone is a little magnesian, contains traces of fossils, which are hardly discernible, and which seem to enter, like those of the limestones of Ahorca Lagarto, with which it has a great analogy with the bivalves, corals, and foraminifers.

Dr. Wagner signalizes the presence of this limestone in several localities between Matachin and Emperador, where he says the same is found here and there in a sporadic state.

It is unnecessary for me to say here that in this section the canal will be built in hard material, and modern appliances, like compressed air drills and dynamite, will play here a great role.

Near Emperador a small hill rises up behind the town, where the company is building one of their villages; and as the whole knoll is composed of a rock, very complex in its nature, I have handed the same for microscopic examination to Professor Hanks.

Some years ago a wagon road was constructed, about five miles long, from Emperador to some gold mines, which were worked by an American company. This mine is located on the banks of the Rio Sandanillo, in a northeast direction from the station; and in company with Mr. Roux, I visited the locality, allowing us to make some observations outside of the line of the tracé, as this is about the only road, excepting by water way, along the banks of the Upper Chagres, where we could safely venture to make observations.

On leaving Emperador, in following this road, we find the grades in a clay of decomposed breccia and doleritic conglomerates, which have passed into an earthy state. After an hour's tramp, we find the greenish and violet colored breccias again, which I have mentioned, in the valley of the Obispo. This breccia seems to form a distinct formation, and from the bearings I took I am of the opinion that it forms a dike some two miles wide, cutting through the doleritic trachytic formation, and that supposition, I think, is proven by its structure at the falls of the Obispo, where its cleavage, indistinct as it may be, is directly across the other formation.

To my notion, this is a distinctly-marked formation, but I am not sufficiently able to fully characterize it and point out its relations to the other formations, although I concede its origin to volcanic action.

In following the bed of the Rio Saldanillo, I found large blocks and bowlders of granite, which were hard to break, where the hornblende and black mica seemed to predominate; but nowhere was I able to find the granite formations in place, and, no doubt, they exist higher up, in regions which no white men have visited so far.

Arrived at the mine I found tunnel shafts, etc., etc., all caved in, and the veins which furnished the decomposed quartz are in a soft porphyry, and the quartz must have contained quite a percentage of iron pyrities, as I found them piled up in sacks near the mill, a good five-stamp battery, horizontal boiler and engine; in fact, one of those monuments of Yankee enterprise as are seen so promiscuously over our States and Territories.

The natives who accompanied us pointed out a big cut made by the "Antiguas," who worked this mine in former centuries, up to the ravine where the veins crossed over to the other cerro, and which cut caved in upon the unfortunate miners, and the locality is to-day called by the natives "Acaco de los muertos" (ditch of the dead), as some sixty men lost their lives in that cave—so the legend says.

About the history of the mine, under its modern management, I could not learn much, except that "El mineral" was not "muy ricco" (a very old story for a Californian).

We followed the creek higher up and interviewed a native woman living with two children in that lonely place, who had quite a reputation for her abilities in gold washing; and after some coaxing and a few drinks of brandy, she produced a vial containing some coarse gold dust. We pushed ahead and followed the bed of the creek, prospecting the gravel, which at first showed only black sand or titanic iron, but very soon I struck colors, but nowhere in paying quantities, and the natives keep it very secret where they find these rich pockets. A Frenchman, who ventured out into that locality alone to prospect, was found assassinated a short time ago. I noticed on the bars, on the bedrock, some good looking streaks of gravel, no doubt the source of the natives' revenues from gold washing.

On our way back, in crossing a hill, I found croppings of iron ore; it is the very best quality of hematite, and seemed to cover the surface of the whole hill; and in drawing the attention of Mr. Roux to the find, he thought that the canal company would be able to utilize this mineral in their foundry, and it may become valuable in the near future.

I draw the attention to the important change in the formation, as soon as we leave the tracé of the canal. I only regret that I had no means at my disposal, nor is there any possibility to get any idea of the country to the west of the line of the canal, as some interesting conclusions have been drawn as to the formation of the isthmus.

From the station of Emperador to the summit of La Culebra, for a length of four kilometers, I have had already occasion to mention the decomposed deep formation covering the underlying doleritic rocks.

Naturally in some places the hard rocks are visible, as the whole central mass is not decomposed, and large masses of hard rocks are found in place on the surface. In descending from the culminating point of La Culebra to the Pacific, and after traveling about five hundred meters, we find a rocky formation, which is not very hard, of a brownish color drawing to green; the same appears amorphous, but covered with large kernels filled with a white fibrous, crystalline matter, sometimes forming geodes covered with little crystals of quartz. Examined under the microscope, they seem to be formed of a labradoric paste with voluminous crystals of feldspath and grains of pyroxene and oxidized iron. This is a species of solidified volcanic mud, in which the interior chemical reactions have produced these hollow amygdaloidal cavities, which are filled with different minerals, which give it such a characteristic appearance.

This rock is soon replaced by another of an entirely different appearance, to which Messrs. Wyse and Recius, as well as Dr. Wagner, have given the name of basalt; and as far as appearance goes, the same approaches it very much, but as the same does not contain chrysolite, it is very hard to give it this name. The same is met with up to the station of Paraiso, for a length of two kilometers, and even here and there on the Cerro Culebra this structure is found.

Taken as a mass, it appears in several localities to be fissured in all directions, and although these fissures form configurations giving rise to extraordinary figures, these never arrive to have the symmetry and regularity of the columnar or prismatic structure basalt assumes. At other points this rock appears in a more compact form, without any fissures; the same is found in some railroad cuts, some soundings, also along the shores of the Rio Grande, where the same crops out to quite a height.

When nearer examined, the same is olive-colored, almost black, with a resinous luster and conchoidal fracture. Its paste is formed of a mixture of labrador and pyroxene in small crystals, with quite a quantity of iron oxides. On some points again, always keeping its luster, this rock becomes yellower, and its grain coarser, the crystals of pyroxene and labrador acquire larger dimensions, as can be seen under the microscope or without it, and they inclose, with the iron oxides, some greenish substance; also some crystals of feldspath are observed.

At Paraiso the conglomerates reappear, and have the globular shape, with well defined concentric exfoliations, but very soon they make place to clays, which are more or less compact, and in which fragments of the original elements are found, and at Pedro-Miguel they are cut through by conglomerates of the above nature again.

The last section, starting from Pedro-Miguel out to Panama, is very clearly defined from a geological as well as topographical standpoint.

The dark pyroxenic rocks make place as soon as we have crossed the alluviums, brought down by the Caimitillo, to whitish and violet-colored tufas, which are amorphous, amygdaloidal, whose elements are sometimes fine, sometimes coarse, and which seem to constitute not alone the small mound between the Rio Caimitillo and the station of Rio Grande, but also the different hills which are met by the Rio Grande and Panama, where they change alternately with some reddish lean clays, which seem to be a modification of these tufas.

These tufas have a great analogy with those which we have studied on the other side of the divide on the Atlantic slope, but I wish to point one out, situated three kilometers before arriving at Panama, which is rather curious. The same is of a very fine grain, more compact than the others; its fracture is slightly conchoidal, and under the microscope we discover crystals of quartz and broken feldspath, embedded in a paste entirely amorphous, in the body of which are seen traces of small grains of chalcedony, laid out in flexible lines bringing to mind those of obsidian.

In a general way it can be said that in this section the rocks are not so hard, and also rarer than in the preceding one, and the alluviums from the river play a more important part. The railroad runs for the most part in earthy embankments, especially in the crossings of the Caimitillo, Cardenas, Corosal, and the Rio Puente; and from Pedro-Miguel to Panama we find notably trachytic tufas and clays of different grain, hardness, and state of decomposition.

This examination will be wound up by the study of that portion of the ocean shore extending from Panama to the mouth of the Rio Grande, which is of importance to the outlet of the canal.

At Panama, on the shores, we find, especially at low tide, a reddish rock, in very heavy layers, which Garella called sandstone, but which Mr. Boutan claims to be a trachytic tufa, in which the microscope discerns, in the body of an argillaceous matter, the presence of numerous nodules filled with a decomposed matter of a shiny luster; as it effervesces under acids it denotes the presence of lime. In following along the seashore, and directing ourselves toward the mouth of the Rio Grande, its nature changes; from red violet its color passes to gray; the paste becomes finer, and its hardness greater. The rock contains no lime, and the layers frequently change with stratas of a wine-colored clay, whose elementary composition ought to be identical to the preceding one, but whose hardness is less and falls into powder under the action of atmospheric agencies. These layers contain here and there knolls of a hard substance, which is black and gives fire when struck with steel, with an oligoclasic paste interspersed with small limestone cells, containing fragments of microscopic bivalve shells; and Mr. Boutan has even found a shell in it whose length was three millimeters and had a spiral form.

It is very hard to give any direction to these stratas, as they are too much contorted.

In going along further, these tufas give place at the foot of the Gavilancito to a grayish trachyte, which is found also at Cerro Ancon. The eye can only distinguish a grayish mass, with some small indeterminable crystals, but under the microscope it can be seen that its paste, oligoclasic and chalcedonian, is filled with abundant crystals of orthoclase and labrador, with iron oxides and some green spots, which may be pyroxene.

The presence of this rock is noticeable over a large extent on the Pacific slope, and is also found on the other side of Panama for a great distance. On the Rio Grande side, the same makes room, on the contrary, to dark doleritic rocks, which not alone constitute the Cerro San Juan, on the right bank of the Rio Grande, but also exist on the left bank, between the Rio Grande and the Gavilan, and have a great similarity to the Paraiso formation, especially the lighter colored ones, with the resinous luster, having the same labradoric and pyroxenic crystals.

I wish to notice here a very interesting phenomena to which the natives at Cruces drew my attention: In digging little pot-holes in the red clays occurring in that locality, there will gather in the bottom, in the course of a few hours, quicksilver pure and bright. In making several of these holes in the evening, quite a little crop of mercury can be gathered in the morning. The natives told me that for a mile and a half in length above Cruces the soil will yield up in this way its mercurial impregnation; but nowhere have I been able to find traces of cinnabar or other mercurial ores. At Acapulco (Mexico), one of the native boatmen told me that back of the town, in the high cerro, plenty of azogue (mercury) is found in sinking holes, and also treated me to a story whereby a native, after sinking a well and taking out a cup of water, after drinking the same, precipitately dropped dead. After investigation, it was found that under the water a large quantity of quicksilver had gathered, which the poor fellow had swallowed.

Mr. Boutan, in summarizing his report on the isthmus formation, makes the following *résumé*, which I consider very interesting, therefore reproduce the same:

"I wish to give a classification of the ground gone over, as the varieties met with are only in such a small number.

"Taken from a petrographic standpoint, I can distinguish, in the first place, the crystalline rocks, all of igneous origin, whose decomposition and disintegration have formed the totality of nearly the whole ground; and in the second place, the breccias, tufas, sandstones, etc., etc., derived from them.

"The crystalline rocks again can be subdivided into three species: The first, the most basic, has for type a dark-greenish rock, sometimes olive-colored, with a conchoidal fracture, with a grained and crystalline texture, with a resinous luster, less compact than the basalt, from which it is distinguished by the absence of peridot. By decomposition this rock becomes brownish-green or yellowish, and even with the naked eye, crystals of augite can be discerned.

"Under the microscope, the same appears principally composed of labrador, in crystals mixed with augite and oxidized iron in the interstices. With the augite appears often a greenish material, which seems to be derived from the alteration of this mineral.

"Some samples contain large crystals of labrador and orthoclase; others have nodules of opal, and thereby furnish another variety.

"This type seems to be identical to the one Mr. Zirkel describes in his work on North America, and to which he gives the name of augite andesite. But the andesite being principally characterized by the presence of oligoclase, it would seem more rational to reserve that name for another type, and to give to this one the name of trachy-dolerites, which name was given to it by Dr. Marits Wagner, and especially by Mr. Daubree, who examined the samples brought back by Mr. Wyse in 1878, and which it seems to have on account of the large percentage of labrador it contains. The differen varieties of this species are principally met with in large masses, in the center of the divide, between Matachin and Paraiso, and as a conglomerate on the two slopes of the Atlantic and the Pacific, principally at Matachin, La Gorgona, and Mamei, on one side, Paraiso and Pedro Miguel, on the other. Outside of the railroad line they are met with in the massive rocks of Cerro Grande, Cerro de los Hermigueros, and the Cerro San Juan, southwest of the railroad; the Cerro Gamboa, Mitra, and La Culebra to the northeast. These rocks form the elevated mountains in the neighborhood of the central line.

"The species which differs the most from the preceding one is composed of a rock generally gray, a little vitreous, with numerous large crystals of sanadine, hornblende, and sometimes a little black mica.

"Under the microscope, we clearly distinguish these different elements in the midst of a clear paste, charged with little crystals, which are mostly feldspath, but also some crystals of labrador can be distinguished in them; some nodules of rounded quartz, some pyroxene, and iron oxides.

"This rock, which is more acid than the preceding one, becomes earthy by decomposition and approaches the amphibolic trachytes, which can also be called trachyte-syenites in opposition to the basic trachyte-dolerites, which form the first type, and which are characterized by the sanadine and amphibole, as the preceding ones are by labrador and pyroxene. Some samples, which are more quartzy and crystalline, approach the true trachytic types of Hungary and of Var, in France. These are the species I found principally at Baila Monas, and also between Matachin and Barbacoas, on the left banks of the Chagres, where they seem to have derived from the Cerro Comboy. They are found there in the state of conglomerate; but nowhere have I seen them in compact masses.

"At last, between the two types, I can place a third one, which is less characterized, with a conchoidal fracture, of a clear color, varying from gray to greenish and red.

"The character most noticeable in it is that the same is principally formed of oligoclase in undefined crystals, sometimes fibrous, which are associated with chalcedony and pyroxene, but the last is in smaller quantities than in the first type; amphibole is never found in it, but iron oxides occur therein in abundance.

"Therefore it seems to me very rational, in consequence of the presence of oligoclase and pyroxene, to give it the name of augite-andesine, which name Mr. Ziakel has applied to a rock which approaches more the first type.

"The rocks of this class seem to be met with on the Upper Chagres, and I have only seen them in the pebbles near Cruces, on the banks of the river, whereas the two others I have seen in place.

"To these three varieties of crystalline rocks we have to count others more compact, more amorphous, but evidently of the same origin, and must be considered as having been generated as they are, without having undergone any changes I note especially:

"1. The compact trachytes of the Cerro Ancon and the neighborhood of Panama, which cannot be counted among the preceding trachytic series on account of the absence of amphibole, nor in the doleritic series, on account of their clear color and their oligoclasic composition, nor among the intermediate series on account of the absence of pyroxene. Their physical aspect gives them an entirely different appearance.

"2. The curious formation of Bubio Soldado, representing a compact volcanic mud, whose composition approaches the doleritic series, as well as the trachytic tufas in the neighborhood of Panama and Barbacoas.

"To these generating rocks, and to their conglomerates, are attached a number of different groups of tufas, sandstones, clays, etc.; but they are all products of the preceding formation. They extend to quite a distance from both sides of the railroad.

"The ground which is composed of them takes quite an importance on both sides of the divide between Pedro Miguel and Panama on one side, and Barbacoas and Colon on the other. Several of them are fossiliferous. We have to count among this category the tufas of San Pablo, of La Loma del Tigre, Gatun, Monkey Hill, as well as the clays scattered in a great many points, notably at Gatun, Tabernilla, and La Gorgona.

"As to the formation of the Bay of Panama, which Garella calls a sandstone, and in which Dr. Wagner finds the presence of crystalline primitive rocks, like granites, syenites, etc., I must state that I have been unable to discover the same, and I have already said that in looks they approach very much the true trachytic tufas."

It would be very interesting to examine the country from a stratigraphical standpoint, so as to establish the relations which exist between the different sections among themselves, their order of superposition, etc.; but it has been noticed in the description given that the points of observation are rare, and consequently the reader will not be astonished when he is told that this is a very difficult task on account of the impossibility to observe the points of contact, to form any kind of a basis for an argument which can only be supported by some isolated facts. The complete absence of determinable fossils in all sections, with the exception of the last tertiary formation on the Atlantic slope, makes the discussion still more difficult; but, nevertheless, I will reproduce some ideas Garella has given on the subject.

Garella admits four distinct formations:

"1. The porphyritic and trap formation, which is the most extensive, and which includes the rocks of all the mountains of the isthmus, from the neighborhood of Panama to the last foothills of the mountain-chain of Varro Colorado.

"2. Sandstone and graywacke of transition which show themselves at Panama and on the slopes of the Cerro Grande, and to which also belong the rocks of Barbacoas.

"3d. A secondary formation which is seen in one point below Vamos Vamos, admitting that the Barbacoas rocks belong to the preceding formation.

"4. At last sandstone and tertiary fossil limestone formation, the most extensive after trap and porphyry formation, and which includes the section which extends between the Rio Trinidad and the ocean on the left banks of the Chagres, and on the right bank, all that extends to the Bay of Limon."

He concludes his report, and as his deductions are of great importance, as they are based on the hypothesis that exactly where the line of the canal is, there, at former geological periods, existed a natural channel connecting the two great oceans, which again was filled in by subsequent disturbances.

This theory I think the scientific world will adopt, as proofs will be brought to light to corroborate the ideas of this eminent engineer.

He closes his argument as follows:

"I will also add, but with the distrust which is imposed upon me by the small extent and the rapidity of my observations, that the trap and porphyry formations have been upheaved at a posterior date to the terrains of transition, and cutting through these latter, raising them up on some points, like on the slopes of the Cerro Grande, and covering them up with argillaceous ejections which have formed these argilophyres, which are found in many distant localities, and of which the mountains where the Rio Chagres on one side and the Rio Trinidad on the other have their headwaters, and which at former geological periods formed the advanced extremities of the two continents of North and South America, and which were separated by a narrow strait, which through the appearance of porphyries was filled up."

Dr. Wagner, less explicit, approaches, like Garella, the formation of the conglomerates of the red plastic rocks of Panama (that is the name which he gives them) to the red sandstones of the permian formation, and assimilates to the zechstein the dark schists which cover them (this is the name which he gives to the gray tufas at the foot of Ancon Hill). He limits himself by adding that all the sedimentary formations of the interior are of more recent origin and derived from submarine volcanic formations during the tertiary period.

As to these volcanic formations, he divides them in two classes: the basic or doleritic rocks, and the trachytic or older rocks, and covered by the preceding ones.

Dr. Wagner is evidently right, as all the soundings along the line have demonstrated that the doleritic rocks overlie the trachytic formation.

Mr. Bouton also thinks, like Dr. Wagner, that the rocks of submarine volcanic origin which are found between Colon and Panama ought to be divided in two principal categories, corresponding to the above petrographic division; that is to say, into the doleritic series and into a trachytic series.

But in the doleritic series other varieties have to be distinguished which probably have not come at the same time, or if they have, they are of different origin; among those have to be counted the group of the different crystalline trachy-dolerites (Culebra, Matachin, El Pueblo), the breccia of the Obispo Falls, and the volcanic mud of Buhio Soldado.

The trachytic series is not sufficiently known as yet to establish any categories.

However the doleritic series is the most recent, and overlies the trachytic.

This is an important fact, offering a perfect concordance with the phenomena observed in countries where igneous formations exist, and especially in Hungary, where the rocks have a great analogy with those of the isthmus.

Outside of these two categories there are only contemporaneous formations to these or more recent ones, as they are formed at their expense, and among these latter are comprised the tufas of Panama, on account of their mineralogical composition and their trachytic elements. Probably in the near future more convincing proofs will be obtained to determine their age, especially on account of the fossils which they inclose; but the samples I took with me were not sufficiently clear to be determinable.

The tufas of Barbacoas, to which Garella gives, under the name of sandstone, a sedimentary origin, and to which in a doubtful manner he attributes the same geological epoch as to the rocks of Panama, are also trachytic tufas much different from the preceding ones and contemporaneous to the trachytes.

As to the limestones of Vamos Vamos and Ahorca Lagarta, whose origin is very difficult to explain, Garella assigns them to the secondary period. He may be able to support this hypothesis; but the fossil shells which they contain, and especially the orbitolites, which are also found in the limestone of La Campana, seem to place them rather at the outset of the tertiary period.

Therefore the observations can be summarized as follows:

At the locality where the Isthmus of Panama is to-day was formerly a strait, more or less wide, which united the waters of the Atlantic with those of the Pacific; that this strait has been filled up, at least in part, by submarine trachytic flows in the first place, and afterward by doleritic flows; that between the two epochs or periods of these flows a long lapse of time existed, during which took place the formation of a large part of the trachytic tufas and probably also the calcareous formation of Ahorca Lagarta; and at last that the whole has been upheaved, forced upward at the commencement of the tertiary period, and about at the same time as the postnummulitic system of the Pyrenees, and received at that time about the relief and conformation of the land as it presents itself to our eyes to-day.

The soft tufas, clays, etc., in horizontal layers, which extend between Gatun and the Atlantic slope, belong certainly to the tertiary epoch or our contemporaneous period.

EXPLANATORY OF THE GEOLOGICAL AND MINERALOGICAL TERMS USED IN THE PRECEDING CHAPTER ON GEOLOGY AND PETROGRAPHY.

Amorphous.—Without crystallization in the ultimate texture of a solid substance.

Amphibole—See hornblende.

Amphibolic.—Pertaining or resembling amphibole, or partaking of its nature and characters.

Amygdaloid.—A variety of trap or basaltic rock, containing small cavities, occupied, wholly or in part, by nodules or geodes of different minerals, particularly agates, quartz, calcareous spar, and the zeolites. When the embedded minerals are detached, it is porous like lava.

Amygdaloidal.—Pertaining to, consisting of, or having the nature of an amygdaloid.

Alluvium.—Deposits of earth sand, gravel, and other transported matter, made by rivers, floods, and other causes upon land not permanently submerged beneath the waters of lakes or seas.

Augite.—A mineral also called *pyroxene*, belonging to the silicates of magnesia series. Occurs crystallized in oblique prismatic forms, and also massive, lamellar, granular, and fibrous, and presenting usually some shade of green, but sometimes white or black. It consists chiefly of silica, magnesia, lime, often with oxide of iron and sometimes oxides of manganese. It occurs as a constituent of lavas, trap, and basalt, and also of many other crystalline rocks.

Andesite.—Is a silicate of alumina, containing some peroxide of iron, lime, magnesia, potash, and soda. Color white, gray, greenish, yellowish, flesh red. Belongs to the feldspar group.

Breccia.—A rock composed of angular fragments either of the same mineral or different minerals, united by a cement and presenting a variety of colors.

Brecciated.—Consisting of angular fragments cemented together.

Bivalves.—A molluscous animal, having a shell consisting of two parts or valves, joined together by an elastic ligament at the cardo or hinge; or a shell consisting of two parts, which open and shut (like an oyster).

Basic.—Having the base in excess, or the amount of the base atomically greater than that of the acid, or exceeding in proportion that of the related neutral salt.

Calcedony or Chalcedony.—An uncrystallized translucent variety of quartz, having usually a whitish color, and a luster nearly like wax. It often occurs lining or filling cavities in amygdaloid and other rocks. These cavities are nothing but little caverns, into which silicious matters have filtered at some period. When chalcedony of different colors is arranged in stripes or layers, it constitutes agates, and if the stripes are all horizontal, it is onyx. Chrysoprase is green chalcedony, colored by nickel. Carnelian is flesh red. Sard, a grayish red variety.

Conglomerate.—Composed of stones, pebbles, or fragments of rocks cemented together.

Chrysolite.—A mineral composed of silica, magnesia, and iron, varying in color from a pale green to a bottle green, and occurring in glassy grains or pieces disseminated in basalt and many lavas, and sometimes in large embedded crystals. It occasionally occurs in other rocks. It is infusible. (Peridot.)

Conchoidal.—Having elevations and depressions in form like the valve of a bivalve shell—applied principally to a surface produced by fracture.

Dolerite or Trap.—A heavy igneous rock, of a greenish black or grayish color, consisting of an intimate mixture of feldspar and hornblende or (augite) pyroxene.

When consisting of hornblende and albitic feldspar it is called diarite; when of pyroxene and albitic feldspar it is dolerite or trap; when in the latter chrysolite is present, basalt; when containing nodules disseminated through the rock, amygdaloid.

Emerald-Beryl.—A mineral of great hardness, and when transparent, of much beauty. It occurs in green or bluish-green six-sided prisms, and consists of silica, alumina, and the rare earth glucina. It is identical with the emerald, except in color, the latter being colored by oxide of chrome, and the beryl by oxide of iron. The beryl, when transparent, is set as a gem, and called aquamarine

Foraminifer.—A minute protozoan, or compound group of protozoans of the tribe rhizopods, characterized by having a calcareous shell perforated by pores or foramina.

Feldspath-Orthoclase.—A mineral occurring in crystals and crystalline masses, somewhat vitreous in luster, and breaking rather easily in two directions, with smooth surfaces. The colors are usually white or flesh red, occasionally bluish or greenish. It consists of silica, alumina, and potash. Feldspar is one of the essential constituents of granite, gneiss, mica, slate, and porphyry, and enters into the constitution of nearly all volcanic rocks

Graywacke.—A conglomerate of grit rock, consisting of rounded pebbles and sand firmly united together. (See Wacke.)

Granite.—A crystalline, unstratified rock, consisting of quartz, feldspar, and mica, and presenting usually a whitish, grayish, or flesh red color. It differs from gneiss in not having the mica in planes, and therefore in being destitute of a schistose structure. It is a true igneous rock.

Hematite.—An important ore of iron, the sesquioxide, so called because of the red color of the powder—also called specular iron, oligist iron, a rhombohedral iron ore.

Hornblende.—A common mineral, occurring massive or in prismatic crystals and of various colors, from white through green shades to black. The crystals are often long and slender, blade like or mere fibers. The black variety is called hornblende; the green, actinolite; the white, tremolite; the fibrous, asbestos. This mineral consists essentially of silica, combined with magnesia, lime, or iron.

Jasper.—An opaque, impure variety of quartz, of red, yellow, and other dull colors, breaking with a smooth surface. It admits of a high polish, and is used for vases, seals, etc.

Labradorite.—Usually in cleavable massive forms. Color dark gray, brown, or greenish brown. Bright chatoyant colors. Composed of silica, alumina, large percentage of lime, and distinguished from feldspar by dissolving in muriatic acid. A constituent of some granites, and was originally from Labrador. Polishes fine—jewelers use it therefore.

Limestone.—A kind of stone consisting largely and chiefly of carbonate of lime, from which lime is obtained by the expulsion of carbonic acid gas.

Mica.—A mineral capable of being cleaved into elastic plates of extreme thinness. It is either colorless or presents some shade of light brown, gray, smoky brown, black, and occasionally green, or violet. It is generally more or less transparent, and is used like glass, in lanterns and in doors of stoves. There are several varieties. Composition: Silica, alumina, potash, peroxide of iron, fluoric acid, and water.

Madreporic.—A coral of the genus madrepora, the species of which usually branch like trees and shrubs, and have the surface covered with small prominences, each containing a cell. In a popular sense, other branching corals and sometimes corals generally.

Microlites.—*Pyrochlore*, so called on account of its minute

crystals, is a mineral of a yellowish or brownish color, consisting chiefly of columbic acid, lime, and protoxide of cerium, and sometimes titanic acid, with or in place of the columbic acid.

Metamorphic.—Certain changes which minerals or rocks may have undergone since their original deposition. Usually supplied to changes which sedimentary rocks have undergone through the influence of heat.

Nummulite.—A fossil of a flattened form, resembling a small coin, belonging to the tribe of rhizopods or polythalamia, and common in the early tertiary period.

Opalescent.—Reflecting a milky or pearly light from the interior.

Oligoclase.—A feldspar like mineral of a white color, or white with a shade of yellow, gray, red, or green, consisting chiefly of silicate of alumina, with a small proportion of silicate of soda or the silicate of lime, or both.

Orbitolites.—A fossil of a flattened form like nummulites.

Orthoclase.—See feldspath.

Oligist.—Specular iron ore, presenting a steel gray color, and a brilliant luster when in crystals.

Obsidian.—Is a volcanic glass. It resembles ordinary glass. Black and smoky tints are the common colors. In Mexico, it was formerly used both for mirrors, knives, and razors.

Opal.—A mineral consisting of silex in what is called the soluble state, containing a small quantity of water.

Pyroxene.—See Augite.

Primitive Rocks.—Rocks supposed to be first formed, being irregularly crystallized and aggregated without a cement, and containing no organic remains, as granite, gneiss, and the like.

Peridot.—See *Chrysolite.*

Protozoan.—An animal of the lowest of the five grand divisions. They have no mouth, or only such as may be formed by a depression of the surface at the time when a particle of food is to be received and digested. They include the rhizopods, sponges, and many of the so-called animalcules.

Porphyry.—A rock consisting of a compact base, usually feldspathic, through which crystals of feldspar are disseminated. The crystals are of a lighter tint than the base, and often white.

There are red, purple, and green varieties, which are highly esteemed as an ornamental polished stone.

Permian.—Belonging or relating to the period, and also to the formation, next following the carboniferous, and regarded as closing the carboniferous age and paleozoic era.

Rhizopods.—One of the protozoans, having usually a calcareous shell consisting of one or more minute cells, and often arranged in regular forms. Some of them extend out fiber-like processes through the pores of the shell; hence the name. The shell-covered species are also called foraminifers and polythalamia. The rhizopods have been of great geological importance, especially in the cretaceous and tertiary periods.

Secondary Rocks.—Those rocks or strata which are situated over or above the azoic and below the tertiary.

Sandstone.—Consist of small grains, aggregated into a compact rock. Have different shades of color. Some are compact or hard, while others break or rub to pieces in the fingers. They are of all geological ages, from the lower silurian to the most recent period. The "old red sandstone" is below the coal in age, while the "new red" sandstone is more recent than the coal. Red sandstone, when used as a building material, is often called freestone.

Shale.—Is an argillaceous rock, fine grained, having a slaty structure, more or less brittle.

Spar.—A mineral that breaks with regular surfaces, and has some degree of luster. Composition: lime, carbonic acid, sometimes impure from mixture with iron, silica, clay, etc.

Tertiary Epoch.—The first period of the age of mammals, or of the cenozoic era. The rock formation of the period.

Titanic Iron.—Oxide of iron, with a variable proportion of titanic acid or oxide of titanium. Is found in gravel mines forming a portion of what miners call "black sand." It has no value.

Tufa.—A soft or porous stone formed by depositions from water, usually calcareous tufa. A volcanic sand rock, rather friable, formed of agglutinated volcanic earth or scoria; also, a similar rock of trap or basaltic material.

Wacke.—A rock nearly allied to basalt, of which it may be regarded as a more soft and earthy variety. Its color is greenish gray, brown, or black. It is opaque, yields easily to the knife, and has often a greasy feel.

Zeolite.—A mineral species in the early works on mineralogy, now subdivided into several, both on chemical and crystallographical grounds. Some of them are stilbite, natrolite, apophyllite, scolecite, laumonite. The term is now used to designate a family including these and other hydrous silicates of alumina, with some of the earths or alkalies. These species are most abundant in the cavities of the amygdaloids, basalts, and lavas, though occasionally found in granite, and gneiss. They are always subsequent in origin to the formation of the containing rock.

THE EXPANSION OF RAILS.

SHERIFF LEES, Glasgow, has just decided a case of some importance to railway companies. Annie Scott Reid, Rutherglen, sued the Caledonian Railway Company for £500, in consequence of injuries sustained through a train in which she was seated leaving the rails between Strathaven Junction and High Blantyre, on the 17th July, 1880. The principal defense of the railway company was that on the day of the accident there was extraordinary heat in the Blantyre district, which caused the rails to expand and get distorted so much as to cause the engine to run off them. The accident was thus caused through circumstances over which they had no control, and for which they were not responsible. After hearing evidence, the sheriff awarded the pursuer £250. In a note the sheriff says: The pursuer maintains that the defenders were at fault in the laying of the line, or at any rate, in omitting to maintain a sufficient space between the ends of the rails. Nothing is more familiar in railway construction and maintenance than that provision must be made for the expansion of the rails through temperature. A 24 foot rail at a heat of 130° is almost exactly $\frac{1}{16}$ inch longer than it is when at a temperature of 32°. Now, as a rail in use could not, owing to its conductive capacity, be raised to 130° by any solar heat that occurs in this country the defenders are, I think, justified in maintaining that if in laying the line they left $\frac{1}{16}$ inch between the ends of rails laid in frosty weather, they took adequate precautions against accidents occasioned by expansion of rails. The rails here were laid in May, 1880, and therefore if an interval of $\frac{1}{16}$ inch were observed, it would probably be ample. This is no direct proof that, as matter of fact, this amount of interval was observed or maintained, and the pursuer found on the absence of such proof. But it is to be remembered that the mere fact of the train going off the line does not necessarily infer liability on the company's part. There are certain circumstances, such as collision between different trains on the same line, where *res ipsa loquitur* both presumes and proves fault. But in the case of a train going off the line, the inference is not so strong. "It is impossible," said the Court of Exchequer Chambers, in the case of Bird *v.* the Great Northern Railway Company, 4th December, 1858, "to say that the accident itself, even if *prima facie* proof of negligence was conclusive proof of it. And if not, then, as there was evidence on both sides, the question was for the jury." In other words, if it be alleged that the railway was badly constructed, the fact that the train went off the rails will be *prima facie* evidence of fault on the company's part, and it will be for them to rebut this presumption. Now, here the defenders have brought a considerable amount of evidence to show that they were thoroughly aware of the necessity for laying and keeping the rails properly apart, and took elaborate precautions to insure their being kept so. And, therefore, what the defenders have to show is that in what they did they took all reasonable care to see that all proper precautions were taken. In Redhead *v.* the Midland Railway Company, a railway company were held not responsible for an accident to their train through a latent defect in a wheel that could not have been discovered by them or the makers. In Nugent *v.* Smith, Lord Justice Mellish pointed out that "in order to prove that the cause of the loss was irresistible, it is not necessary to prove that it was absolutely impossible for the carrier to prevent it, but that it is sufficient to prove that by no reasonable precautions under the circumstances could it have been prevented." And in many English and Scotch cases, proof that skilled men, good materials, and proper regulations had been used, of itself went far to negative the presumption of fault. Therefore, if matters stood thus on this point, I should not hold the fault proved. But they do not do so. It will not do to say such proof *must* be sufficient. If precautions which should suffice for safety, and suffice for safety under the like circumstances everywhere else, fail in one particular spot, there is room for the presumption that these precautions were not duly taken then. Now, the defenders maintain and make it part of their defense that the train went off the line through the expansion of the rails caused by the great heat of the sun; and here two important facts have to be noticed. About two hours before the accident a train had gone up the line safely, and shortly after the accident the down line was found to be impassable at a point about twenty yards further back, as the rails had so expanded with the heat that on any attempt being made to force them straight they sprang into a bend the opposite way of $3\frac{1}{4}$ inches to $4\frac{1}{2}$ inches off the straight; and before they could be used $4\frac{1}{2}$ inches were taken off the rails, and the gap at their extremity distributed by shifting several adjoining rails to a greater or less extent. It was explained that $4\frac{1}{2}$ inches were taken off, not as being the excess in length over that required for safety, because if more or less were taken off a new hole would require to have been drilled through the rails for the bolts where the rails are fished. The engineers who were examined by the defenders were all of opinion that the expansion had made the rails bend upward, and that they were broken by the engine before the train left the line. There is also evidence to show that the heat of the day was great. At Glasgow Observatory, the maximum temperature was 129°; there were $11\frac{1}{10}$ hours of sunshine, and no rain fell that day. In this state of matters the defenders say that circumstances were so unprecedented that the occurrence was a *damnum fatale*, for which they are not responsible. It is therefore necessary to consider what is a *damnum fatale*, and whether the circumstances were unprecented. Erskine III., 1·28, terms *damnum fatale* an accident which can neither be foreseen nor withstood, and in the case of Tarrant *v.* Earl of Glasgow, 3d March, 1804, the Lord Chancellor—Westbury—describes such a calamity in the law of Scotland as being the result of "occurrences and circumstances which no human foresight can provide against, and of which human prudence is not bound to recognize the possibility." Plainly, therefore, a *damnum fatale* is a loss due to the occurrence of something that could not reasonably have been expected, and not to the recurrence of something that might reasonably have been expected. Now, the expansion of the rails from heat is admittedly a circumstance which is expected, and which is able to be provided against, and is, as matter of fact, so capable of being provided against that the engineers of the London and Northwestern, North British, Caledonian, and various other railways, who were examined, had in all their experience met with only three instances of railway lines being distorted by expansion from heat, and of these three cases the present case is the only one that was not timeously obviated. Nothing is shown why heat should have affected the rails of the High Blantyre line more than those of any other line in the kingdom, and the absence of bad effects elsewhere favors the presumption that there must have been fault of some kind here. In the case of the Great Western Railway Company of Canada *v.* Fawcett and McBraid, it was held that "a railway company in the formation of their line are bound to construct their works in such a manner as to be capable of resisting all violence of weather which in the climate through which the line runs might be expected, though perhaps rarely, to occur." But was the heat unprecedentedly great on the 17th July, 1880? There have been put in evidence tables showing fully the maximum of heat recorded at the Glasgow Observatory during May, June, July, and August in 1879, 1880, and 1881, and less fully for some years before. On 1st July, 1880, the maximum temperature was 129°. In 1862 there were two occasions on which the maximum temperature equaled or excelled this —3 in 1873, 0 in 1874 and 1875, 9 in 1876, 13 in 1877, 17 in 1878, 4 in 1879, 5 in 1880, prior to 17th July, and 7 after it, and 19 in 1881. If it be assumed that the heat at Glasgow Observatory is a fair indication of the relative heat of the days at High Blantyre, there is thus no room for the idea that the heat was anything abnormally great there on the 17th July, 1880. But I have also been furnished with tables showing the maximum temperature in the shade at the Glasgow Observatory, and the amount of moisture and of rainfall during July, 1880. On 17th July of that year the temperature in the shade was higher than it, any other day that month. There was probably, therefore, less breeze. On the four other days of July, when the temperature was as high as on the 17th, the data are as follows:

	Mean tem. deg.	Do. in shade. deg.	Hours of sun	Rain-fall.
4th July.....	132	65·2	12·1	0
17th "	129	73·2	11·1	0
20th "	133·9	66·3	10·3	0
25th "	130·4	71·0	10·5	0
30th "	130·1	61·2	9·7	0 22

There is of course no certainty that the heat was similar and not greater at High Blantyre. Mr. Blyth is led to think that it must have been greater that day, but making all charitable allowance for an inference of this kind, I think there is no reason which would justify me in holding that the heat was, in the words of Lord Westbury's definition, such that no human foresight could provide against it, and that no human prudence was bound to recognize the possibility of it. Indeed, the tables show that on three or four occasions before 17th July, 1880, and after the line had been formed, the maximum temperature was about a dozen degrees above what it was on that day. Now the precautions taken to prevent injury by expansion of the rails are, first, to lay them properly; secondly, to examine them regularly and sufficiently; and, thirdly, to shorten or readjust the rails if necessary. Mr. Dundas, one of the defenders' engineers, in his intelligent evidence fully explained the tendency of the rails to travel or creep together owing to the passage of the trains. It is not very clear whether the rails travel in the direction the train goes in, dragged by the wheels which are thought to skid along the line to some extent, or whether they are pushed by the wheels in the opposite direction. But for the decision of this case it is not necessary to inquire. It seems to be thought that this creeping of the rails, owing to the gradient, slow pace of the train, and expansion would be down hill from High Blantyre. If so, and if gradually they crept together, one would expect the buckling of the line to occur further downhill on the down line than on the uphill; and this was what actually did occur. When therefore this circumstance is borne in mind that the heat was no greater that day than on fifty-three previous since the formation of the line, that on almost all of these days it was greater and on some much greater, that on no other line of railway in the kingdom is it shown that the rails were similarly affected to a dangerous extent, that on this line they have not since then got into the like dangerous condition, that to guard against such danger is in practice a matter of no difficulty, and that on the down line the distortion is so great as it is owned to have been, this conjunction of circumstances points, I fear, with unmistakable distinctness to the view that the proper intervals between the ends of the rails reasonably required for the safe use of the line had not been adequately preserved.

PHILADELPHIA AND LONG BRANCH RAILWAY.*

By C. S. D'INVILLIERS, C.E.

THE Philadelphia and Long Branch Railway, finished during the past year, was built with the object of developing a portion of the New Jersey coast lying south of Sea Girt, and known as "Squan," or more properly Manasquan Beach, taking its name from the Manasquan River, which empties into the ocean near the northern end of it.

The peculiarity of this beach is its extreme narrowness, being from only 600 feet to half a mile wide, and separated from the mainland by the waters of Barnegat Bay, a sheet of salt water varying from one to six miles in width. The railroad starts at a point called Whitings, which is distant 16 miles from the sea, and is the terminus of a series of roads 40 miles in all, starting at Camden, and controlled by the Pennsylvania Railroad.

After traversing an almost due east course to Barnegat Bay, it crosses the same on a pile-bridge $1\frac{1}{2}$ miles long, and turning a right angle, runs northwardly 12 miles up the narrow strip of beach to a connection with the Central Railroad of New Jersey, securing thus a through line to Long Branch, some 12 miles shorter than the one at present used from Philadelphia to that point.

If we omit the severe weather of January and February, 1881, but few difficulties were encountered between Whitings and the shore, the country traversed being a gently rolling one, through which the cuts and fills, though sometimes long, were in no case more than 17 feet deep, and this portion of the road, begun in December, 1880, was opened for travel in July, 1881.

On the beach, the principal problem was to guard against the inroads of the sea, which, as you all perhaps know, becomes very violent in stormy weather. And it is to discussing this matter that I desire to confine my principal attention.

We were considerably—I do not know whether to say exercised or amused—by the oldest inhabitant, who told us before commencing that a railroad would never stand on the beach; that the sea was known at times to go clear over the narrow strip of beach into the bay, and would carry the railroad with it. I have seen nothing to justify these predictions, though I do not pretend to foretell what the future might bring forth.

A cross section of the beach would show first a gradual upward slope from the sea toward the bay for from 100 to 300 feet until an elevation of from 15 to 25 feet is reached; this elevation being the summit of what are known as *sand dunes.* The slope is then downward, at first abrupt and then gradual, to the bay.

The sand dunes are broken quite frequently, leaving the gaps, called glades, through which the sea passes at storm-tide, and even in some cases at ordinary high water. The crest of these glades is generally eight or nine feet above tide. Over this the water comes perhaps from one to three inches, at ordinary high-water, and three to eight at storm-tide, and having a downward course toward the bay, the volume rapidly accumulates with each successive wave, so that before reaching the railroad it becomes a running stream eighteen inches or two feet deep.

It was at first proposed to build pile bridges over all these glades, but as this was expensive and the glades numerous, the following much simpler plan was adopted, and has worked quite successfully, preventing the water from coming through the glades at all:

On the crest of the glade a row of old railroad ties was planted on end, being placed three or four feet in the sand or down to water, and an inch apart in the clear; then a quantity of brush placed before and behind the ties, at first parallel and then at right angles to the sea, and sand thrown up outside of this to a height sufficient to prevent ordinary storm-tides from passing over it. The dike thus formed is 8 feet wide on top and 15 or 20 at the bottom, and in this state is only, I might say, commenced. We rely on nature to finish it, as it has done already in several places, for every time the tide comes to the dike, it leaves more sand on the ocean side, and every time the west wind blows, it carries sand to the other side; the result, in a year or two, is a sand dune more solid than its neighbors.

None of this work was done until the road was finished, and where the embankments were made across the glades, wooden boxes were placed under them for temporary drainage. It was the intention to have all the diking done before

* A paper read before the Engineers' Club of Philadelphia, April, 1882.

NEW BRIDGE, HARLEM RIVER, EIGHTH AVENUE, NEW YORK—WEST SIDE AND YONKERS RAILWAY COMPANY.

the winter storms began, but as this was not accomplished, the necessity of having them, and the utter uselessness of box drains, was shown by the banks being cut entirely away in several places, and the boxes carried a quarter of a mile into the bay. About 7,000 feet of dike have so far been built, and probably 600 or 700 feet remain to be done. The average cost is 10 cents per lineal foot. So the saving in not building bridges has been considerable, as they would have cost about $7.

I forgot to mention that the reason for placing the ties a small distance apart was to give free passage for the sand to collect among the brush. The accumulative power of sand, where there is anything to form a nucleus, is astonishing. I have seen places, where a few sticks and pieces of grass have collected, in two years, sufficient sand to make a hill four or five feet high.

The question of providing against attacks or encroachments by the ocean is quite a serious one among the landowners on the coast, and in some places rather expensive plans have been tried.

At Bay Head City, near the upper end of the beach, a plan has been tried, and, I believe, a patent taken out on it. It is there used to protect some cottages built on the sand dunes, and consists in planting squared timber every few feet, down to the level of low tide and sloping toward the ocean; then planking the face, and dovetailing into the planking, posts running diagonally downward some distance back into the sand hills. This plan seems to work very well, but costs $2 a foot as against 10 cents for the plan we adopted.

At Seabright piling has been tried and failed.

Already developments have been begun at several places on the beach, notably at Berkeley.

This place is situated just north of where the railroad first reaches the beach. As I had the pleasure of starting the work at this place, I hope a few words about it will not be amiss. The sand hills have been graded to a uniform level north and south, and an almost uniform pitch from an assumed crest near the ocean, toward the bay. The first question which arose, was how high it was necessary to make this crest to prevent the ocean coming over. This was a very important question, as, if made too low, the whole property would become but one vast glade, and yet, as sand was scarce, it was desirous to cut the hills as low as possible. It seems, perhaps, strange to say that sand was scarce, but I mean by this that there was not enough at some places in the hills to fill the low places. Moreover, I might add, that if you do not own any, you will find it a difficult thing to get now, though it was not considered worth enough to pay taxes on a year or so ago.

After many inquiries at Ocean Grove, Spring Lake, Ocean Beach, and other places where the heights ranged from 12 to 16 feet, 13 feet was adopted, and has, I believe, proved amply sufficient. A slope resembling a parabola was used from this point toward the bay. The sand when graded is covered with mud, taken from the meadows west of Barnegat Bay, to a depth of 10 inches, except where streets occur, where it is covered with from 4 to 6 inches of gravel. The mud shrinks to the same level as the gravel. After the saltness is out of the mud, it is proposed to sow the same with the seed of blue grass, lawn grass, and oats, and eventually have a fresh grass meadow. About twenty acres have so far been prepared, and I believe it is proposed to have ten more ready before the summer.

HARLEM RIVER BRIDGE.

THE West Side and Yonkers Railway, New York, is a corporation that was formed for extending the elevated railway system on the west side of New York city over the Harlem River to connect with the surface roads in West Chester county, particularly the New York City and Northern Railroad (once the New York, Boston, and Montreal Railroad). This connection is about a mile long, commencing at the end of Eighth Avenue, the terminus of the Metropolitan elevated line, and ending at High Bridge, the commencement of the New York City and Northern Railroad, above noted. The principal engineering feature of the work is the bridge over the Harlem River and its approaches, shown in the engraving opposite. In view of the contemplated improvements of the Harlem River by the General Government, the restrictions thereby created involved, 1st, a rectangular crossing with the contemplated bulkhead lines; 2d, a draw span admitting of not less than 120 ft. uninterrupted water way either side of the pivot pier; 3d, masonry to be founded with reference to a future 18 ft. channel at low water. The above restriction of location involved the approach work on a curve at either end of 450 ft. radius. The whole work is for double track and proportioned on a somewhat lighter basis than is usual for first-class American bridges, since it can never be subjected to heavy freight engines or freight traffic. The river bridge consists of a central draw span 300 ft. long, and a deck span of 100 ft. at either end, provided with footwalks on either side in view of contemplated streets along the proposed bulkhead lines laid out for the river improvement. The above is all pin-connection work, and is supported on granite piers. The approach work on either side consists of riveted lattice and plate girders, the lattice work being so designed as to make the center lines of the web members intersect in the center lines of the chords. The riveting was more carefully performed than is usual in American work of that character, the holes all being punched small, and reamed out when parts were assembled to receive the rivets. The piers for the approach work are Belleville brownstone coped with granite. These piers were placed radially to the curves of approach, and were located and instrumentally maintained by a system of triangulation and intersecting lines. No direct measurements were made for any of the piers, and the whole has been a model of careful field work performed under the immediate direction of Mr. C. L. Cooke, principal assistant engineer in charge of the work. The foundations across the river and on the New York side are on piles, and on the West Chester side they start from the alluvial drift. They were all obtained by means of coffer dams, excepting the pivot pier, which was founded by means of a caisson with movable sides. The mode of coffer-damming was by driving a single row of tongue and grooved 6 in. planking with a pile driver, bracing internally as the water was lowered and excavations made. At the site of the bridge, the Harlem River bed consists of a plastic mud varying from 6 ft. to 20 ft. in depth overlaying a deposit of sand from 5 ft. to 15 ft. in thickness, under which is found a stiff clay running out to a knife edge on the West Chester side, where the alluvial drift is immediately below the sand. The 18 ft. channel involved piercing through the mud into the sand, and the above device for coffer-damming answered an admirable purpose, against a head of, at times, 22 ft. of water. Frequently the sand in the bottom gave a great deal of trouble, boiling springs breaking through and frequently carrying a stream of sand from under the toes of the sheet piling plank. Ordinarily an 8 in. pump would hold the bottom until piled, but one foundation was exceedingly troublesome, requiring a 12 in., an 8 in., a 6 in., and a 4 in. pump to hold the bottom until piled and concreted. The granite employed in the river bridge was in two colors, dark and light, the latter being used for coping, weathering, and band courses, which was all bush hammered work, and the former rock faced for the body of the piers. The red sandstone approach piers are all rock faced, which contrasts handsomely with the light granite coping. The draw span is the portion of the superstructure of more special interest, it being up to date the largest double track draw in the world, and is rather novel in general design and details. It was computed on the theory of no end reaction whatever from the dead load, when closed and loaded on one or both arms, the usual assumption now made in America for continuous drawbridges. There being an ambiguity at best, in proportioning such bridges, a single system of web arrangement was adopted in panel lengths of 17 ft. 4 in., the diagonals toward the center being in sets of four. The truss is 20 ft. deep at ends, and 40 ft. deep at the center. There are two trusses 26 ft. apart centers, with sidewalks cantilevered out from suspended cross girders. The turn table is a rim-bearing table solely, made with extreme care, machine faced, and turned in all moving parts. While the truss delivers its load to four central posts, the bearing table is so arranged as to divide on eight symmetrical points on the drum, thus distributing the whole weight over all the wheels. The machinery for operating the draw is all within the table, and consists of a double (5 in. × 7 in.) cylinder oscillating engine, with shafting and friction clutches. The free ends of the draw are supported on cams, connected with the levers of which are a system of toggle joints and levers, for raising the rails clear and free from the permanent work, the whole being operated from the central engine by line shafting beneath the floor. The mechanical attachments are such that with the first movement of the capstan wheel which connects the engine with friction clutches raises the rails, following which the cams are drawn, when the span hangs free. The second motion of the capstan throws the table shafting into gear and the bridge swings. An indicator in front of the operator always shows the exact position of the bridge and defines its centering position. The turn table is also provided with hand motion, and on a still day three or four men can readily open the draw.

The engine and mechanical details were supplied by Joseph Edwards & Co., of New York. The flooring system of the whole structure is heavily timbered and guarded, making it impossible for a derailed engine to endanger the structure. The time occupied in construction was one year from commencement to the passage of trains, although considerable additional time was absorbed in general finishing touches, painting, etc. The following is the schedule of spans, with weight of iron employed in same—all double track. Commencing terminus Metropolitan Elevated Railroad:

	Lineal feet.	lb.	
4 Lattice spans, each ..	60	234,224	on curve 450 ft. radius.
1 Pin connection.....	100	166,125	river bridge.
1 "	300	711,758	draw span.
Turn table, gearing, locking gear, etc.....	—	179,472	
1 Pin connection.....	100	166,125	river bridge.
3 Latticegirderspans,each	60	175,668	on curve 450 ft. radius.
1 Skew lattice span	89½	123,823	on curve 450 ft. radiusoverNew York City and Northern Railroad.
Lineal feet plate girder viaduct.....	276½	197,351	on curve 450 ft. radius to tangent point on abutment.
Totals.....	1,386	1,954,546	

Mr. Alfred P. Boller is chief engineer, and Messrs Clarke, Reeves & Co., contractors for the iron work; Smith, Ripley & Co., general contractors.—*Engineering.*

OBSERVATIONS ON MASONRY BRIDGES.

AT present metallic bridges are in many cases employed in preference to those of masonry, the reason being due to the lightness with which they can be constructed, and consequently the saving that can be effected by adopting such a mode of construction. However, when we examine the question more closely, we find that masonry bridges might be erected more cheaply than they usually are, and that their cost might be reduced below that of a metallic bridge, or even of a wooden bridge, of the same span. Finally, as concerns the height of the work, it is well to remark that we may take as the pitch one-twentieth the aperture of the arch, and, under such circumstances, have a profile approaching that of a metallic bridge. But, in order to obtain such advantages, the construction of masonry bridges must be submitted to certain rational rules; and these consist in the use of brick masonry vaults whose extrados and intrados surfaces are not concentric.

There may be cited a series of bridges erected on the lines from Berlin to Potsdam, Anhalt, Dresden, and Goerlitz, on the following principles:

1. The forces that act upon the vault are transmitted directly to the soil, whose resistance to compression has been previously tested.

2. The different parts of the work are constructed according to different, but perfectly definite, conditions, which depend upon the forces to which such parts are submitted.

It was in conformity with the preceding rules that the upper passage on the Lubeck-Bochen line was constructed. This passage has served as a type for several other works of the same kind, and finally for the Stassfurt bridge, which has a total length of 57 meters, and arches of 14 meters aperture. This last named work cost less than a wooden bridge would have done.

If we take, for example, the bridge shown in Fig. 1, which has an aperture of 7 meters and a spring of 1 2 meters, we find that, under a movable load of 400 kilogrammes per square meter, the pressure supported by the masonry will be, at the most, equal to 10 kilogrammes per square centimeter, and that transmitted to the ground be equal to 2 kilogrammes per square centimeter.

Fig. 2 represents a section of another bridge constructed on the same principles. The centers of this bridge were taken down eight days after its completion without the production of any cracks, or without any settling taking place. Twelve days afterward the vault was loaded with 400 kilogrammes per square meter without producing any injurious effect, and then iron rails were laid down which increased the load. The latter reached the figures 3,000 and 5,322 kilogrammes per square meter. As yet no fissure has been observed in the masonry submitted to the enormous pressure of 75·5 kilogrammes per square centimeter. Such pressure is admitted, in fact, only for stones of a peculiar nature.

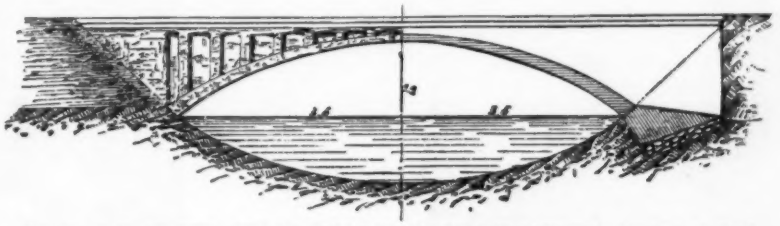


FIG. 1.—ELEVATION AND SECTION OF MASONRY BRIDGE.—(Scale 1 to 100.)

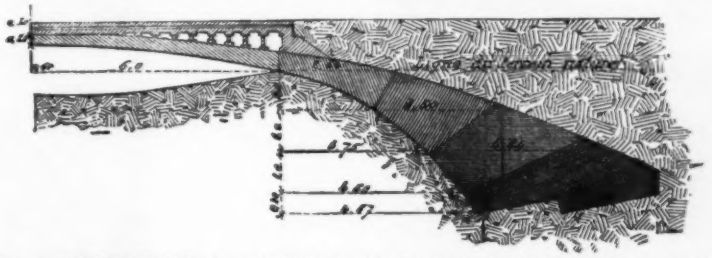


FIG. 2.—LONGITUDINAL SECTION OF MASONRY BRIDGE.—(Scale 1 to 150.)

The arch in question was made of bricks of a perfectly regular form and of exceptional quality. It is with materials of such a nature that it is possible to construct very elliptic and long span arches at a relatively small expense. We may cite, as another example, the Etienne bridge over the Danube Canal, at Vienna, the pitch of which is 2·5 meters and the opening 58·5 meters. This bridge, which is oblique, has a thickness of only 1 meter at the key, and the masonry resists a pressure of 60 kilogrammes per square centimeter.—*Les Annales des Travaux Publics.*

BRICKWORK UNDER WATER-PRESSURE.*

By D. McN. STAUFFER, C.E.

ONE of the most troublesome problems presented for solution to the practicing engineer, is the construction of watertight masonry. And while brickwork is well adapted for such construction, and is extensively used, the porous nature of the material increases the difficulty in direct proportion to the height of the water column to be confined.

During the connection of the writer with the construction of the tunnel under Dorchester Bay, in Boston, force of circumstances made it necessary to build a water-tight brick bulkhead that had to resist the pressure due a water column 162 feet high. This experience is so exceptional that it was deemed a sufficient warrant for the writing of this paper, setting forth our trials and failures and ultimate success.

The rock through which the above mentioned tunnel was driven in its entire length is made up of alternating strata of red slate and conglomerates, much disturbed by upheaval, seams very frequent, and the beds tilted at angles of about 80° with the horizon. The material overlying the rock is sand, gravel, and bowlders, forming a very porous stratum, which was in direct communication with the waters of the bay above. As a consequence of this arrangement of material, water was abundant in the workings, and each seam cut by the tunnel section added an additional quantity to the water already on hand. The tunnel itself being practically an inverted siphon, all of this inflowing water had to be forced to the surface, at an enormous outlay for pumps, boilers, and fuel. To give an idea of the work done, we might mention here, that with 6,000 lineal feet of tunnel driven, the amount of sea-water raised 162 feet every twenty-four hours, was 12,000 tons, equivalent to nearly two million "foot-tons."

At the bottom of one of our shafts, with 1,000 feet of tunnel driven each way, we had two No. 11 Knowles pumps at

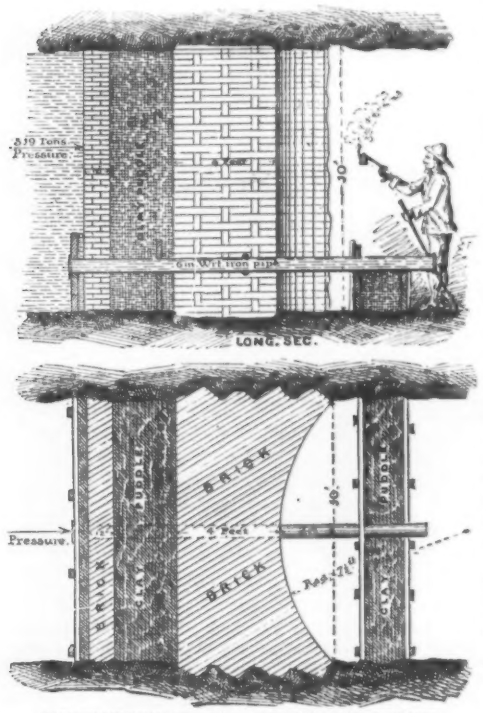
* Read before the Engineer's Club, of Philadelphia, April, 1882.

work, but the amount of water pouring in, in this length of excavation, was just about equal to the full working duty of one pump. As the pumps required frequent packing and repairs, safety demanded a reserve pumping capacity, equal at least to the maximum inflow, as a breakage of any part of the working pump might necessitate a stoppage of a day or more. We had reached in this way the limit of safety at the shaft mentioned, when the workmen suddenly uncovered an unusually large seam in the rock, adding 10,000 gallons per hour to the supply on hand, and setting both pumps at work. This destroyed our reserve power and threatened disaster, in case of accident to either pump. Two horns of a dilemma were presented to us, either to increase our pumping capacity at an immediate heavy outlay for pumps, and a constant increase for fuel, or to stop work in the effected heading, and attempt to shut out the water last struck. As under the conditions of the case, we lost nothing by stopping in this particular heading, we determined to try the second plan, though it implied a bulkhead subjected to enormous pressures.

A point was selected for the location of the bulkhead, where the rock appeared to be most solid, without seams to pass the water around our wall. Such a place was found about 50 feet in front of the seam where the tunnel section was practically 10 feet square. Throwing out of the question any loss from friction in passing through the intervening strata, the pressure per square inch, due a column of sea water 162 feet high, would be 72 1/10 pounds (taking sea water at 64·08 pounds per cubic foot). This would be equal to 10,382 pounds per square foot, and as our bulkhead presented 100 square feet, the total pressure was about 519 tons—no mean force to contend with.

After the rock had been carefully examined and all shaky portions removed, a plank dam about 3 feet high, filled with puddle clay, was thrown across the tunnel just back of the site of the proposed bulkhead; through this dam was led a 6 inch wrought-iron pipe, about 2 feet above the bottom, having a broad iron flange screwed on to its inner end. The outer end of the pipe went through a second dam to prevent interference from back-water, and between these two dams the brickwork was started.

An arched form was adopted for the bulkhead, 4 feet



BRICKWORK UNDER WATER-PRESSURE.

thick at the crown and 2 feet rise in a span of 10 feet. Skewbacks for the arch were roughly cut into the rock at the sides.

Hard-burned brick was used, laid in a cement mortar of the following proportions: One part English Portland, one part Newark Rosendale, and two parts clean sharp sand. This compound, by actual experiment, gave equally good results with English Portland, used one of cement to one of sand, and had the advantage over the last named mortar of working smoother with the trowel, and adhering more readily and firmly to the brick, when used in wet places.

The bond was well broken, and laid in such manner that there were no continuous horizontal joints through the wall. The mortar was freely used and well rubbed into the joints, and the inside of the wall parged with cement as far as possible. On the completion of the brickwork, and after the cement had been allowed a sufficient time to harden, the flow of water was shut off from the tunnel by screwing a cast-iron cap on the outer end of the 6 inch pipe.

For the first forty-eight hours our wall proved perfectly tight, a very small quantity of water escaping at one or two points, where the brickwork joined the rock. But when the 50 feet of tunnel back of the bulkhead was entirely filled, and the pressure due the full hydraulic head began to exert itself, water commenced to ooze out all over the face, amounting finally to about one-half of the original quantity from this seam. As well as it could be observed under the circumstances, the water seemed to come through the brick rather than from the joints, and upon being tasted, the water appeared much less salt than that usually entering the tunnel.

This first attempt at shutting off the water not proving satisfactory, we determined to try again, taking advantage of a hint thrown out as one of the results of our first experiment. It was observed that no water escaped the lower 3 feet of the bulkhead—just that portion covered by the original clay puddle dam. This clay being so effectual for a portion of the wall, there seemed to be no reason why it should not act equally as well, if applied to the whole back.

This we proceeded to do as follows—the water behind the wall was let out by opening the 6 inch pipe. As there was considerable pressure upon the 6 inch cap, provision had been originally made to relieve this pressure in a degree, by having a 1 inch hole tapped into the center of the cap, and fitted with a plug; this plug was first removed, and the cap then started with comparative ease. The bulkhead wall was next taken down far enough to permit the bricklayers to pass behind it, and a second brick wall, only 12 inches thick, was started behind the main wall, and 2½ feet distant from it. As the lighter wall was built up, puddle clay was packed into the intervening space and well rammed; the second wall and the clay packing were carried to the roof—both being of course finished out from the front; the main bulkhead was rebuilt as before. The back wall was made purposely light, so that it might yield somewhat to the force applied, the only effect of which would be to more thoroughly consolidate the clay between it and the unyielding wall in front.

After a time, the water was again shut off, and our second experiment put to test, and in this case perfect success crowned our labors.

AUTOMATIC FIRE EXTINGUISHER AND ALARM.

THE recent catastrophes at Nice and Vienna have directed the attention of inventors to a means of preventing, in the future, disasters such as these that have stirred up the whole world.

Among the numerous solutions of the problem that have been proposed, one of the most ingenious is that of Mr. Hiram Maxim. Fig. 1 gives a general view of this inventor's system. The upper part of the stage is provided with a system of tubing of various diameters, which, under ordinary circumstances, are filled with slightly compressed air; and the water, under pressure, is held in check by a cock that is seen in the figure under the foot-lights. The arrangement of this cock is represented on a larger scale in Fig. 2.

Situated at various distances at the upper part there are cocks which, in their normal position, are kept turned off and held by a detent as shown in detail in Fig. 3. The detents are connected with combustible cords stretched at dangerous points, and which serve to hold them in position. In case of a fire the cords are parted by burning, the cocks under pressure runs into the system of tubing and flows out, through apertures corresponding with the burned cords, in the form of a powerful jet (Fig. 4).

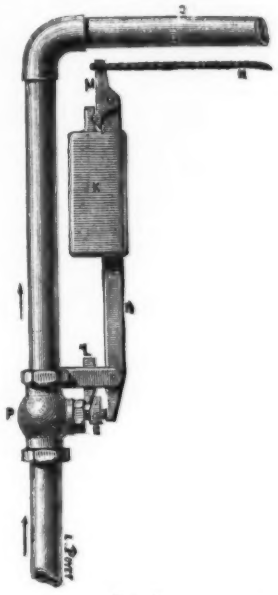


FIG. 3.

The maneuver of an ordinary supply cock demands considerable effort, but the inventor has here conceived the ingenious idea of causing the fire itself to supply the amount

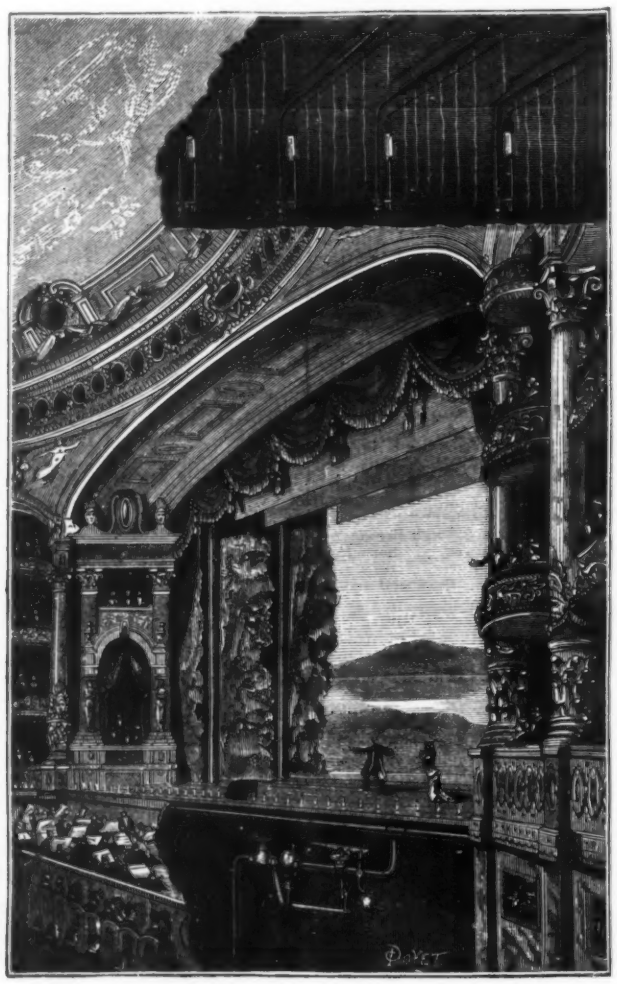


FIG 1.

of power necessary, by bringing about the dropping of a weight. Mr. Maxim has gone a step further with his invention, and introduced electricity as a substitute for the purely mechanical arrangements described above. At the most

open, and the air which fills the tubing escapes. Then, under the influence of the depression of air, the valve C (Fig. 2), is depressed and unlocks the detent which holds the weight, H, and the latter in falling opens the cock, B. The water

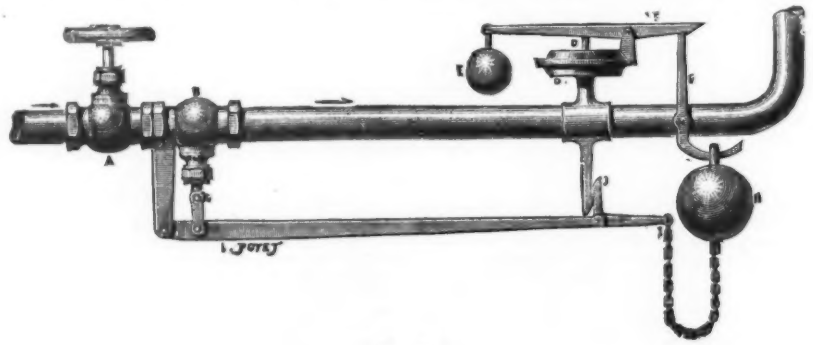


FIG. 2.

dangerous points he distributes a series of alarms which set up electric contacts that act upon bells, and, at the same time, set free the detents by means of electro-magnets. With such an arrangement there is no longer any need of filling the tubing with compressed air, and of arranging a series of cords to be burned by the fire.

Such are the arrangements designed to be used when the water supply has the requisite amount of pressure. When the latter is not the case, Mr. Maxim provides for the insufficiency by the apparatus shown in Fig. 5.

A reservoir full of water, A, carries a dome, D, containing a glass bottle, E, filled with sulphuric acid. At the moment at which one of the alarms is in operation it sends a current into the electro-magnet, H, which attracts the armature, I. The latter in falling unhooks the hammer, J, which strikes against the rod, F, and forces it against the bottom of the bottle and breaks it. The acid then flows into the water, and, coming in contact with pieces of chalk at the bottom of the reservoir, disengages a large amount of carbonic acid gas which exerts a pressure on the water, and forces it through the pipes to the point attacked by fire. In order to open an orifice in proximity with the fire, the inventor employs a Leclanché pile, and arranges at various distances water taps closed by a cap. This latter contains a small quantity of gun-cotton, which is fired by means of a platinum spiral connected with the pile and the fire-alarm.

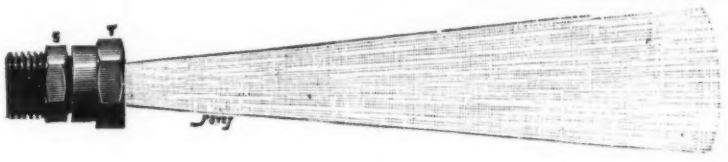


FIG. 4.

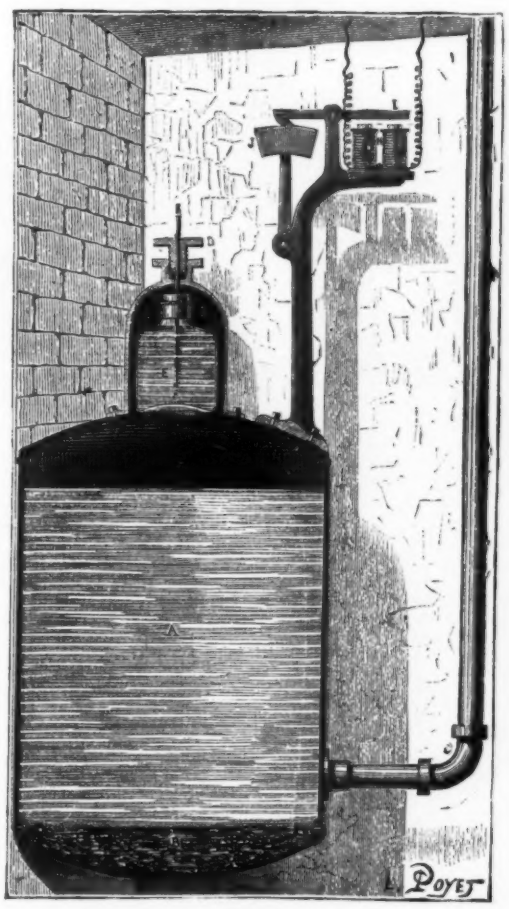


FIG. 5.

The result is that the water under pressure, which has filled the pipes, escapes at the point where the local explosion has taken place as soon as the fire has manifested itself.

DUNAND'S SPEAKING CONDENSERS AND MICRO-TELEPHONE STATIONS.

AT the time the first experiments were presented to the Académie des Sciences, by Mr. Th. du Moncel, we made known to our readers through what means Mr. Dunand had succeeded in making condensers *speak*, these apparatus having been, up to that period, incapable of reproducing articulate speech. The scientific importance of the result was considerable, and showed once again the extreme delicacy of electrical action as well as the exquisite sensitiveness of hearing. We shall not to-day revert to those experiments, but we desire to make known the practical forms that the inventor has reached after long and interesting researches; for the results obtained are remarkable, and the experiments are easy of repetition.

Let us recall in a few words the general arrangements of the system which the diagram in Fig. 1 indicates very clearly. At the transmitting station a microphone, M, a pile, P, and the inducting wire of a small bobbin, B, without condenser, are arranged in the same circuit. The induced wire of the bobbin, B, communicates with the line and a pile of a few elements, P', and the two free extremities are connected with the armatures of a small condenser, C, which constitutes the receiver. On speaking in front of the microphone the intensity of the inducting current is made to vary undulatorily, and there are developed in the fine wire of the bobbin induced currents that cause a variation in the charge of the condenser. These undulatory charges and discharges of the condenser cause it to speak; and this is a phenomenon that no one has as yet succeeded in explaining.

To make the condenser articulate, the presence of the pile, P, is indispensable. The induced currents developed in the induced wire are added to or subtracted from the current from the pile, and the charge of the condenser changes value but always preserves the same direction. This, up to the present, is the *sine qua non* condition of the speaking condenser, and in all cases in which it is fulfilled the condenser is given the faculty of articulation to a greater or less degree.

We now come to the practical form of the apparatus.

The microphone employed by Mr. Dunand is of a new form, which seems to present some advantages. It consists (Fig. 2) of two metal plates, AA', fixed in a wooden ring and forming a hermetically closed box in which the microphone system is entirely shut in from the air and from the dust which so often soils the contacts of ordinary microphones. Each of these plates carries a small carbon disk, BB', glued to its center. Between these disks there is a small olive-shaped piece of carbon, which is a little longer than the distance of the internal surfaces of the carbon disks. This olive is grasped in the middle by a brass wire, F, which is stretched out diametrically, fixed at one of its extremities, and connected at its other with a button, E. On twisting the wire more or less, the olive is applied with more or less force against the two disks, and the microphone is rendered more or less sensitive. An index, fixed to the button, E, moves in front of a divided circle, and permits of the easy graduation of the torsion of the wire so as to proportion the sensitiveness of the apparatus to the nature of the sounds that it is desired to transmit. It is useless to dwell on the well-known fact that variations of resistance are produced by speaking before one of the plates. Two persons, one of them speaking before A, and the other before A', can even transmit a duo, which the receiving apparatus will reproduce with fidelity and clearness, without regard to the insufficiency, often absolute, of the experimenters.

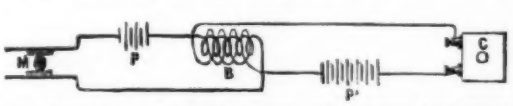


FIG. 1.—MOUNTING OF A TELEPHONIC STATION WITH SPEAKING CONDENSER OF MR. A. DUNAND.

The pile, B, consists of four ordinary Leclanché elements, two mounted for tension and two for quantity.

The bobbin, P, consists of an inducing wire of about a half ohm resistance, and of an induced wire of 250 to 300 ohms.

The pile, P', which serves to charge the receiving condensers, consists of a number of Leclanché elements, varying according to the number of receiving condensers employed. When only two condensers are used (Fig. 3), six to eight elements are sufficient. With the receiver in the form of a fan (Fig. 4), and consisting of twelve distinct condensers, mounted on a derived circuit, it requires twelve to fifteen elements. In this case speech may be heard from a distance of more than a meter.

FIG. 2.—DUNAND'S TORSION MICROPHONE.

All condensers may serve as receivers, but all do not produce equally clear effects. Those that have given the best results are such as measure not over 6 centimeters at the sides. The simplest model consists of thirty to thirty-six sheets of tinned paper separated by sheets of ordinary or of paraffined paper. Solidity is given to the system by a piece of wood or ebonite having an aperture in the middle, and which is applied against each surface. One of the surfaces is sometimes provided with a rubber tube, which allows the apparatus to be heard by two persons at once, or one person to listen with both ears. In another arrangement Mr. Dunand makes use of two condensers on a derived circuit which are mounted on a light spring that the listener places on his head, as shown in Fig 3. Although not very elegant, the system is yet none the less convenient.

FIG. 3.—CONDENSER ARRANGED FOR LISTENING WITH BOTH EARS AT ONCE.

When it is a question of causing the apparatus to be heard by several persons at once, Mr. Dunand employs a fan-shaped receiver (Fig. 4), consisting of twelve small condensers mounted on a derived circuit, arranged in a box open at the top, and separated from each other at the upper part by an interval nearly equal to their thickness. Under these circumstances, with fifteen Leclanché elements placed at P', Fig. 1, the condenser may, as above remarked, be

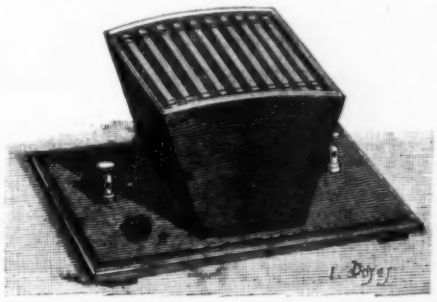


FIG. 4.—FAN-SHAPED CONDENSER, DEVISED TO BE HEARD AT A DISTANCE.

heard from a distance of over a meter; and, with thirty elements, the voice may be distinguished within a radius of 5 to 6 meters.

The condenser employed as a telephone receiver is characterized by the clearness and exactness with which it reproduces the voice, and which is not affected by the sound inherent to the vibrating plate, as in ordinary metal plate telephones.

Mr. Dunand has taken advantage of the practical qualities of his microphone to form a telephonic station of a very practical nature. The apparatus, which is very ably constructed by Mr. Trouvé, is complete in itself. Upon one base in common, there are fixed the microphone, the call-bell, the induction bobbin, a pair of receiving telephones, the call button and eight terminals that are designed to receive the wires of the pile, of the line, and of the two telephones. A micro-telephone station may thus be installed in a very short time, and without possible error. When the telephones are suspended from their supports communications are set up with the call-bells; and, when they are taken down, their supports tilt and set up automatically communications by telephone. When the conversation is at an end, communication is set up again with the call-bells on putting the telephones in place.

The sounds produced by the receiving telephone are much more powerful than those from the speaking condenser, but, as an offset, the voice is more metallic and nasal. This, however, does prevent much inconvenience in current practice.

The results obtained by Mr. Dunand are very interesting, since they permit of the speaking condenser now being heard at a distance. It is to be hoped that this physicist will not stop at this point in his course, but that we shall soon have to register new progresses made by him.—*La Nature.*

APPLICATIONS OF THE PRINCIPLE OF THE PHONODYNAMOGRAPH.*

By WILLIAM B. COOPER.

UPON the evening of the last meeting of the Institute, I gave a brief description of a device for augmenting the dynamic effect of the vibrations of diaphragms, and directed attention particularly to the application to the production of a record of such pulsations in much thicker metal than was heretofore thought possible; on account of the interest manifested by those then present, I have brought the device again before you with the view of entering more at length into its applications.

When a cord is passed over a revolving pulley, it is well known that there is a pull upon one side proportioned to the character of the surfaces in contact and the pressure upon them. This pull is due to the friction of the surfaces upon each other, and increases in approximately (if not exactly) the same ratio as the pressure; now, if the pulley is loose upon the shaft and we draw upon a cord passing over it, we have the same force exerted at the other end of the cord minus the friction of the shaft; if, however, the pulley is attached to the shaft and is rotating toward the end drawn upon, then the result at the other end will be the force applied, plus the amount derived from the friction upon the surface of the pulley. This is the principle of my device. To one end of a wire or band, B, Fig. 1, I attach a

Fig. 1.

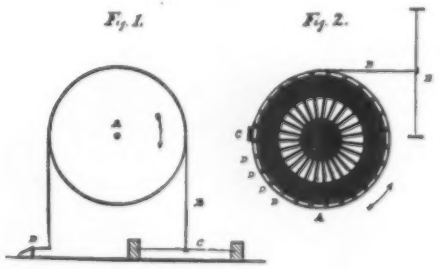


Fig. 2.

diaphragm or other pulsating body, C, and then give a half turn or several turns around a drum or pulley, A; to the other end may be attached a lever, D, having a point adapted to the indentation of sheet-metal passed under it at a uniform speed; this may be accomplished by any suitable mechanism. In this form I have termed it the "phonodynamograph," and my experiments have already resulted in embossing brass of the thickness of writing-paper by the impact of the voice upon a diaphragm of the size used in the phonograph.

This principle is, without doubt, applicable to the telephone, both for the purpose of increasing the intensity of the electric impulses transmitted, and augmenting their effects at the receiving station. At the transmitting station, for example, the same, or by means of leverage, a greater amplitude of vibration may be given to a stouter diaphragm, or an armature controlled by a spring, playing before the poles of a magnet. It is manifestly applicable, however, to any form of transmitter in which increased power is advantageous. By it the telephone may be rendered available for greater distances.

Having augmented the electric impulse at the transmitter, we may add to it an increment derived from an auxiliary power at the receiver. This may be done in several ways; the vibrations of a receiving diaphragm, or an armature in combination with a spring, may be augmented and made to operate a second diaphragm or a recording point. As the dynamic effect of the telephonic impulse is at best but feeble, I have devised a method of dealing with it which appears to me cannot but produce some very strong results.

If a number of electro-magnets, D, D, D, D, D, Fig 2, preferably of the horseshoe form, are arranged radially in a drum or pulley, A, composed of some non-magnetic substance, at right angles to its plane of motion, with their poles flush with its face, it is clear that if an armature, C, is placed in contact with the face of the drum and it is rotated, the armature will be drawn in the direction of the motion of the poles of the magnets whenever an electric impulse passes through their helices; the extent of this motion will depend upon the inertia of the armature, the resistance applied to it, and the strength of the electric impulse, etc. If the number of magnets is such that the distance between their poles at the face of the drum is somewhat less than the width of the armature, and each succeeding magnet makes electric connection before the preceding one has parted from the armature, then there will be a continuous draught upon the armature as long as the electric impulse lasts, subject to the above-mentioned influences; there will clearly be a sensitiveness to slight magnetization owing to the continuous intimate contact of the armature with the poles of the magnets. If we now connect to the armature a wire or band, B, and give it one or more turns around the drum in the opposite direction to its motion, we will have the draught upon the armature augmented by an increment derived through the agency of friction from the power applied to rotate the drum. The other end of the wire or band may be attached to a diaphragm, E, or it may be connected to recording mechanism.

At the work-end of the wire or band the normal tension may be reduced to a minimum by an adjustable spring, while the friction may be increased by increasing the number of coils, the size of the drum, or the nature of the surfaces. A light spring may also be found advantageous at the slack end under some circumstances.

Instead of a wire or band, a chain, one or more shoes hinged together, or coupled by a cord, wire, band, or chain, may be used.

The magnets used in the drum may be small, as magnetization and demagnetization is said to be more rapid in small than in large cores. If made in the horseshoe form as suggested, their poles should be sufficiently separated to leave a zone of uninterrupted friction surface in the middle of the face of the drum. The face of the armature in contact with the drum has a notch or recess over this middle zone to give the band free play.

The principle applied in the above cases is also applicable to the mechanical telephone. It may also be used to reproduce the record in increased sound, as by giving a diaphragm greater amplitude of motion, a louder tone results. A large diaphragm having a funnel or trumpet attached to it, through the intervention of this device may, by means of leverage, be made to vibrate with greater amplitude than the smaller diaphragm at which the pulsations originate. This will be a simple method of increasing the power of the voice in the many cases where that is desirable.

I have also devised improvements in recording the vibrations of diaphragms, etc. A small burr or circular saw, revolving at considerable velocity, may be used, its plane of motion being at right angles to that of a strip, plate, or cylinder against which it is pressed by the pulsations of a diaphragm; or, it may be made to notch the edge of a strip. If it is desirable the burr or saw may be stationary, and a strip may be pressed against it by a small roller, or other device, operated by the diaphragm.

In the case of indenting metal with a stylus, the metal may be acted upon while softened by heat. A strip might be heated by an oxyhydrogen jet just before passing under a stylus of some refractory substance; and in the case of a strip of steel, it might be tempered by passing it immediately into water, or oil, or cotton waste, or some similar substance saturated with them. In this case, also, the stylus or point may be fixed, and the strip pressed against it, if that method should be found more desirable.

* A paper read at the stated meeting of the Franklin Institute, May 17, 1882.

SIEMENS' IMPROVED INTENSIVE GAS BURNERS.

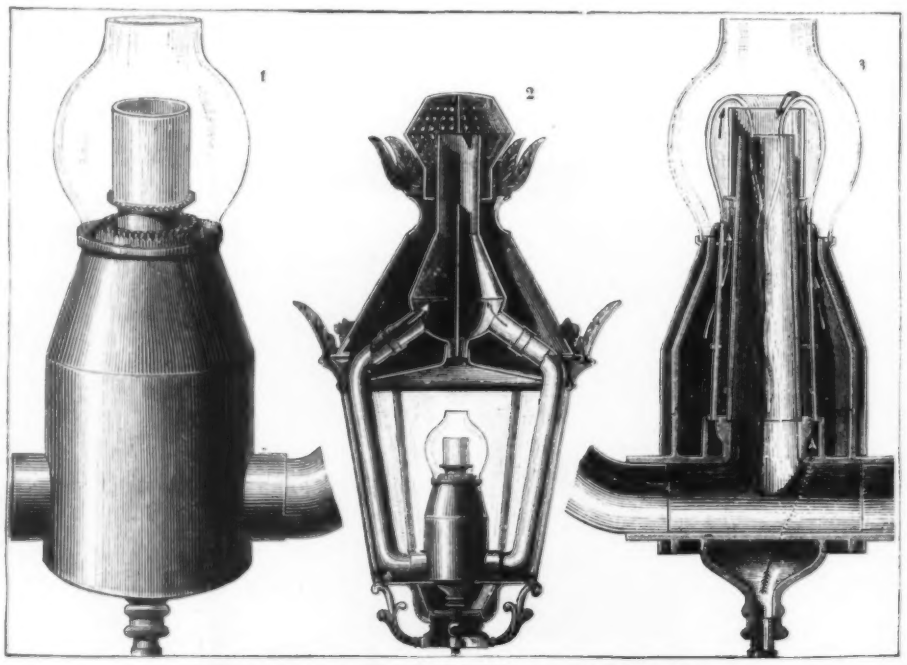
IT would be difficult to foresee which will be successful in the bitter contest that has already been waged for the last three years between gas and electricity for illuminating purposes. Let us be content, as impartial spectators, to register progress in measure as it shall be made, and to applaud every success, since we are the first to profit by it. We have already explained the principles and construction of the intensive burners of Mr. Frederic Siemens, of Dresden, and we have shown that, with an equal luminous power, they used three times less gas than the intensive burners of Rue Quatre Septembre. We revert to the subject now in order to make known the modifications that have been introduced into them, and to describe the type adopted by the city of Paris for lighting Place du Palais Royal. The power of each of the four burners located there varies between 40 and 45 Carcel burners, and the consumption is regulated at a discharge of 1600 liters per hour, thus reducing the discharge to 36 liters per hour and per unit of light, instead of 127 liters as in the ordinary butterfly burners. Let us, in the first place, recall the fact that the principle of the Siemens burner consists in utilizing the heat used for combustion for heating the air and gas, which, therefore, mix together in the flame at a somewhat elevated temperature. Hence the name, "regenerative burners," that has been applied to the apparatus.

The gas enters the flame through a circular crown, formed of 32 tubes 4 millimeters in diameter. This crown surrounds the central chimney, in which the products of combustion circulate from top to bottom in the direction shown by the arrows in Fig. 3, and afterward separate into two branches (Fig. 2), and finally reach the atmosphere by traversing a sort of perforated hood. The air for feeding the flame also enters the lower part of the burner, and becomes heated by contact with the central chimney. The chamber into which the air enters is covered with a nickel-plated copper jacket, which prevents its cooling, and has the form of a cylinder surmounted by a truncated cone (Figs. 1 and 2). The upper part of this jacket serves as a support to the glass globe surrounding the flames. A small portion of the products of combustion escapes directly into the atmosphere by traversing an aperture in the middle of an enameled sheet iron shade, which forms a reflector at the top of the lamp (Fig. 2). This latter is completely closed, so that all the air for supplying the flame is obliged to come in contact with the central chimney and to become highly heated before entering the flame.

Finally, a regulating cock and a rheometer arranged in the lamp support, within reach of the hand, permit of regulating the consumption of the burner.

As regards the effect produced, we may add that it is very satisfactory, and that, thanks to the two tubes of small diameter that have replaced the single one of the old model, the aspect of the burner is more pleasing, since those tubes are almost completely hidden against the sides of the lamp.

In its present form, the Siemens burner constitutes an excellent apparatus for lighting public places and open spaces, and we shall not have to wait long to see the number of its applications multiply, for its place is marked wherever there is sought an intense light without having recourse to the complications that will attend electric lighting, as long as the distribution of electricity on a large scale has not been carried out.—*La Nature.*



SIEMENS' INTENSIVE GAS BURNERS.

APPLICATION OF THE ELECTRIC LIGHT TO SUBMARINE CONSTRUCTIONS.

By C. C. SOULAGES.*

WE have already often had occasion to point out the services rendered by the electric light in building operations whenever it became necessary to finish buildings quickly, and consequently to work at night. At Paris, especially, contractors have often had recourse to the new process, and every one will recall its application in the erection of the Credit Lyonnais, the Eden Theater, and recently again in the Printemps stores.

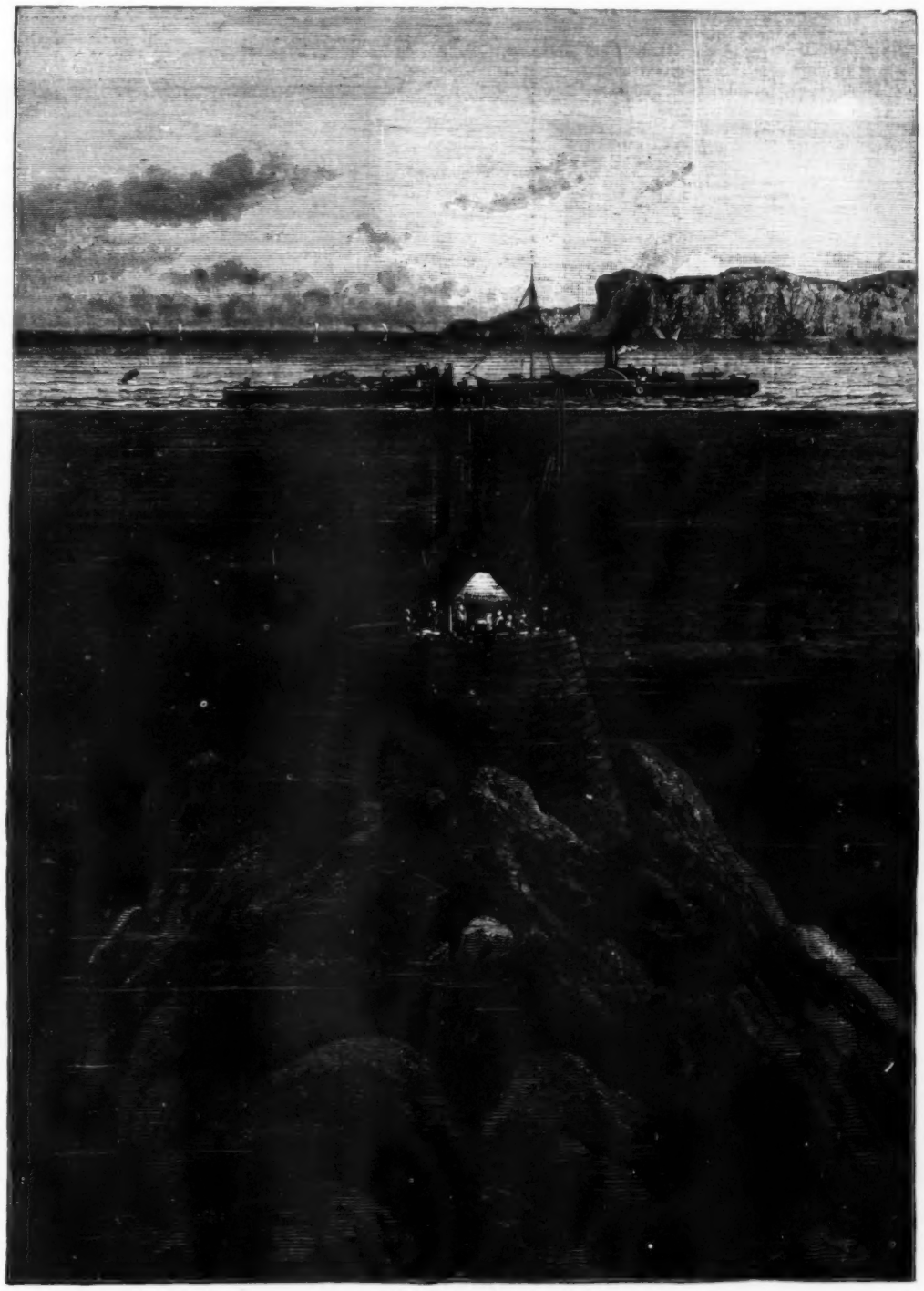
But such applications of the electric light in night work have merely been a very natural extension, and it might have been foreseen that the voltaic arc and incandescence would be utilized to bring to a successful issue the operations, otherwise complicated, of submarine building.

As well known, the electric focus produces light without borrowing anything from the medium in which it is placed; it persists in a vacuum, or in any neutral gas whatever; and it is easy, then, to construct lamps that can be carried into the depths of rivers or of the sea in order to serve in explorations, and to afford light to workmen.

The accompanying engraving gives with great accuracy a general view of the operations that take place in building the foundation of a light house, signal-tower, or any other submarine structure at some feet below the level of the sea. After determining, by means of preliminary explorations, the spot on which the foundation is be laid, lighters loaded with materials are towed to the place, and the steamer which brings the force of laborers furnishes the motive power necessary to actuate the electric machines for producing the light. It is well understood, of course, that the workmen who are to work under water are provided with diving-suits so that they can remain under as long as necessary. Communication with the surface is effected by telephone. Things thus arranged, the work, provided the sea be calm enough, can go on very regularly, and the base of the structure to be raised may be as solidly established as if the work were done on the earth.

This new process has permitted in some cases of doing away with the old system of caissons with beton filling, foundations thus laid not being always capable of resisting the action of the sea, owing to their imperfect adherence to the rocks. This opinion, moreover, was perfectly confirmed some years ago at Lavezzi in the Mediterranean.

* *La Lumiere Electrique.*



THE ELECTRIC LIGHT IN SUBMARINE WORK.

In the middle of the strait of Bonifacio, there is a very dangerous shoal formed of a rock that the sea covers by a few feet only. It was on this rock that was wrecked, in 1855, the frigate Semiramis while bringing troops from the Crimea. After this terrible catastrophe, measures were taken to warn navigators of the spot by anchoring an immense buoy over the fatal rock. But this was destroyed several times by tempests, and therefore about the year 1869, a tower in masonry was substituted for it. Now, the base of this tower had been laid by means of a caisson, and in 1875, another furious tempest carried the structure away. It was only in 1877 that the present signal tower of Lavezzi was finished, it being this time solidly connected to the rocky base by means of strong bars of iron that are sealed in the latter at great depths.

According to the kind of work to be done under water, there may be employed either multiple lights (each workman carrying his own lamp), when the incandescent system will be chosen, or a single light sufficiently powerful to embrace within its radiation the entire submarine work. In the latter case, the apparatus constructed by Mr. Bazin, it appears to us, should give the most satisfactory results. It is his system, moreover, that is represented in the engraving.

Mr. Bazin's combination includes an electric light, which is none other than the Duboscq regulator. It was brought into use for the first time toward the end of the year 1864, in the examination of the *débris* of the Confederate steamer Alabama, which had run into our shores in sight of Cherbourg. The luminous focus is contained in a thick cylinder more than three feet in diameter, and carries underneath an enormous plate of glass. The lower portion of the cylinder is filled with a solution of alum, designed to counterbalance the pressure of the sea water which increases very rapidly in measure as the apparatus sinks. In the upper part there is a powerful electric lamp whose luminous rays pass through the alum water and the glass plate to light a circular space beneath of more than ninety feet diameter.

The second part of the Bazin combination is a large cylindrical metallic case, about 10 feet in height, provided with bull's-eyes, through which an observer can watch the workmen, and even give orders, on account of the excellent conductivity of water for sound; or, if the distance is too great, the orders can be given by telephone. But this cumbersome apparatus, somewhat complicated for management, has never given any very practical results, and the use of it has about been given up since the fruitless attempts made a number of years ago in the Bay of Vigo to find the celebrated galleons. The improvements introduced into diving suits now permit of a proper surveillance being performed without recourse to the above described arrangement.

EXPERIMENTS ON RADIANT HEAT.

PROFESSOR S. P. LANGLEY, of the Alleghany Observatory, finds as one of the results of the Mount Whitney experiments that the true solar constant or amount of heat sent to the earth, is one-half greater than that determined by Pouillet and by Herschel near the sea level, and even greater than the recent values assigned by M. Violle. On the other hand, the temperature of space, so called, is lower than that assigned by Pouillet. If the atmosphere of the earth were withdrawn the temperature of the latter would greatly fall, even though the sun's radiant heat were materially greater than it is. Mr. Langley believes that this temperature under such circumstances would be —50° F.; that is, that mercury would remain a solid under the vertical rays of a tropical sun if radiation into space were wholly unchecked, or even if the atmosphere existing, it let radiations of all wave lengths pass out as easily as they come in. It is not merely by the absorption of the air, but by the selective quality of this absorption, that the actual surface temperature of the earth is maintained. Without this comparatively little-known function, it appears doubtful whether, even though the air supported respiration and combustion as now, life could be maintained upon this planet. Accepting these results as true, the temperature of a planet may, and not improbably does, depend far less upon its neighborhood to, or remoteness from, the sun, than upon the constitution of its gaseous envelope, and indeed it is hardly too much to say that we might approximately indicate already the constitution of an atmosphere which could make Mercury a colder planet than the Earth, or Neptune as warm and habitable a one.

THE FLIGHT OF BIRDS.

MR. F. W. BREAREY read the other day before the London Aeronautical Society a paper on the action of the pectoral muscle in the flight of a bird. Experimenters in artificial flight, he said, should reduce their theories to a demonstrable form. It had often been stated, for instance, that the power exerted by a bird in its flight had been greatly exaggerated, but no one had hitherto proved his assertion. It was capable, however, of satisfactory proof by demonstrating artificially the action of the pectoral muscle, by the aid of which weight became an accesory to power. When the bird committed itself to the air the upward pressure in the wings stretched the elastic ligament, which formed part of the muscle to such an extent as to allow the bird's gliding upon the air without any exertion. The weight of the bird was the measure of this elasticity. It was said by some that at least the bird must possess the power by the downward stroke of the wing to raise its own weight. But Mr. Brearey said that this was not an absolute necessity, because the reaction of this elastic ligament aided the force of the down stroke.

He proceeded to verify his assertion by the action of a model, with wings of four feet spread, under which he had attached an elastic cord passing under the body of the model. Upon committal to the air this just allowed of the wings being expanded, so that the model would glide downward. He then detached the cord and wound up his power, calling attention to the fact that he had wound the India-rubber strands thirty-two times. He showed, however, that although this was sufficient to create a vigorous flapping of the wing when held in the hand, yet when committed to the air it had not the power to give one downward stroke, and therefore it could only glide as before. Holding it again with the cord attached and the power wound up the same number of times, he showed that it was unable to flap the wing, because the two forces were exactly held in equilibrium. There was a third factor wanted before it could fly—and that was weight. The model being liberated, flight was well sustained, and upon being set free several times without being wound up any further, it appeared able to fly with

a very weak power. The same thing was observable with another model, composed entirely of a loose surface thrown into a wave action—his own invention. Mr. Brearey remarked that this economy in flight can only be obtained by something of the nature of wing action, and must be wholly wanting in any apparatus actuated by the screw

PIANOGRAPH-METRONOME.

WE illustrate, by the accompanying engravings, a very curious invention, now being introduced into this country by Mr. Hodgson, of Paris It is called the pianograph-metronome, and is an instrument for effecting the accurate transcription of all kinds of musical compositions. Machines of this nature have already occupied the attention of mechanical engineers, and attempts in this direction have been made as far back as the last century. In 1747 Creed wrote a memoir in which he endeavored to demonstrate the possibility of a transcribing instrument. It is said that in 1770 the monk Engranselle successfully constructed a machine of this nature, and in 1774 Jean Frederic Ungher claimed Creed's invention as his own. In the month of August, 1827, Carreyze made a trial before the members of the Institute of France of a piano-melograph, consisting of a clockwork apparatus, which unwound from one cylinder and wound on another a thin sheet of lead on which were printed certain signs which could be translated into ordinary notation with the help of an explanatory table. About the same time M. Baudouier read to the members of the French Academy a memoir describing another piano-melograph, but neither the Institute nor the Academy took any action in the matter. Many attempts have since been made, but did not meet with success, for this reason, that besides the imperfect, and in some cases complicated mechanical means employed, up to the present the rhythm and the infinite variations of the unity of movement were overlooked. Sounds, indeed, could be reproduced, but without values, intonations, and modes. Supposing even that such apparatus could have been properly worked, mere dots only could be obtained; and as even elementary conditions of musical notation are numerous and complicated, they failed entirely to answer the purpose for which they were constructed. In short, a transcribing instrument has only become possible since the application by Messrs. Winkel and Maelzel of the chronometer to music, hence allowing time in its unit and fractions of unit to be measured.

The pianograph herein described and illustrated in the accompanying drawings is founded on the principle of the metronome, and the inventor has, therefore, entitled it "the pianograph-metronome." It gives the following results: The representation of melodious strokes and intervals corresponding to the duration of sounds and rests which have been executed and based on a certain longitudinal unit previously determined and variable for all movements or vibrations of the pendulum; the movement in which the composition has been performed; notes, chords, diatonic or chromatic scales, trills, appoggiaturas, etc., etc., performed either in the key of G or in the key of F, or in either key when used simultaneously; the intonation of the note played for each of the seven octaves of the keyboard, natural, flat, or sharp, according to cases with its position on the staff in G or F; the mode or key in which the piece has been performed—major or minor—with the necessary sharps or flats indicated on the staff; the accidental sharps, flats, and naturals not belonging to the mode or key actually performed; the beat or time in which the composition is played, whether in $\frac{4}{4}$, $\frac{3}{4}$, or $\frac{2}{4}$; the value of each note or rest for every variation in the position of the weight of the pendulum or balance verge of the metronome from number 40 down to number 208, and this from the semibreve down to the double demisemiquaver for notes, and from the pause down to the sixteenth of the crotchet rest for rests; notes in the ratio of 3 to 2 or triplets; the exact value of graces, voluntary pauses, appoggiaturas, etc; if necessary the change of time or mode during the course of the piece performed; the instantaneous transposition from the mode actually performed to any other mode as it pleases the composer or the copyist. With this instrument it is not at all necessary that the composer should proceed himself to the copy. Any person, whether possessing or not a knowledge of elementary music, can reproduce on music paper, and, according to the ordinary rules of musical notation, what has been printed by the instrument, and this just as well as if the composer himself had undertaken the work. The pianograph can be used like any ordinary pianoforte, and cannot transcribe but through the working of a hand lever situated on the left-hand side of the keyboard. The instrument admits of continuous impression.

Description of the Instrument.—The instrument consists of three different parts—an upright piano, the printing apparatus, the noting apparatus.

The Upright Piano.—The upright or cottage piano is of the usual form, with the exception of some slight modification of details. The keyboard is a revolving keyboard, and the instrument can be used as an office desk. The metronome is placed on the right hand side of the instrument.

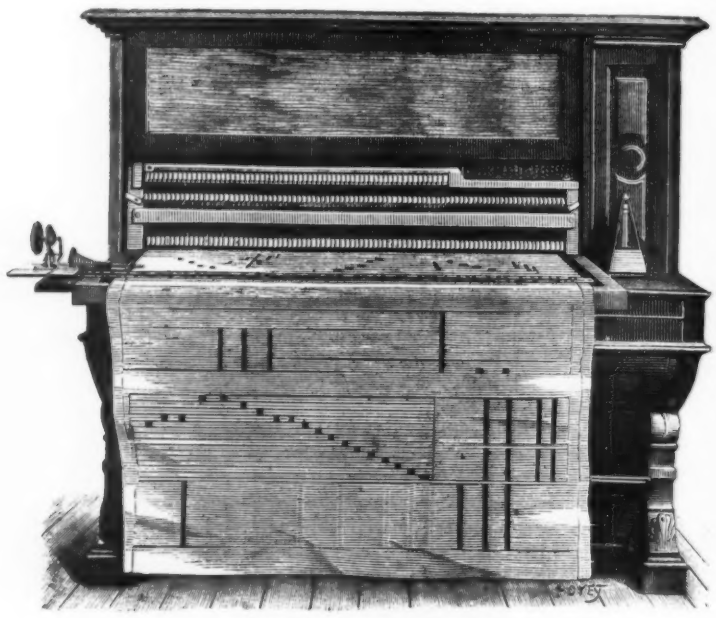
Printing Apparatus.—The working of this apparatus is founded on the "metronome" and on the "inverted staves" principle. It is divided into four parts, viz., the keyboard with its metronome, the printing nibs or pens, the printing cylinder, the motive power.

Keyboard with its Metronome.—This keyboard is exactly the ordinary seven-octavo pianoforte keyboard. It revolves on a pivot, each key being fitted underneath with a transmitting hammer, so constructed as to preclude any friction or hardness in the note when acted upon. The metronome placed outside is the ordinary Maelzel's chronometer, comprising the different gradations of movement from 40 to 208.

Printing Nibs or Pens.—Two different contrivances have been adopted. The first one shown on our illustration consists of printing nibs or pens in equal number with the transmitting hammers, and therefore with the notes of the keyboard. They are made of two flexible brass plates and run in a parallel direction with the printing cylinder, from which they are equally distant. Ribbons supplied from reels located on the upper part of the pens run between the brass sheets, and passing on the foremost part of the nibs, are finally fixed in their position by an adjusting piece situated at the back of the pens. The lower part of the pens, the nibs, and ribbons dip into an ink trough, which can be set in motion upward and downward through a handle. The ribbons once impregnated, the nibs through the mere force of capillary attraction remain constantly wet without however being loaded with ink, and a continuous impression is thus obtained. In the second contrivance the ribbons are replaced by movable casters of a proper diameter and resting on a wet roller. This roller is of the same length as the keyboard, and dips in the ink trough above mentioned, being fitted on its right hand side with a toothed wheel driven by the printing cylinder's cog-wheel. The casters, always in motion, are supplied with ink by the roller, and when acted upon by the transmitting hammers they come into contact with the printing cylinder or matrix paper, and an impression is thus obtained, the circumference of the casters being so calculated as to be equal to the semibreve.

Printing Cylinder —This cylinder is horizontal and of calculated diameter. It is situated underneath the keyboard,

KEYBOARD UP.—SHOWING PRINTING APPARATUS WITH MOTIVE POWER.



KEYBOARD DOWN.—NOTING APPARATUS.

FRONT VIEW WITH KEYBOARD DOWN.

KEYBOARD DOWN.—SHOWING NOTING APPARATUS AND MOTIVE POWER.

THE PIANOGRAPH-METRONOME.

and the paper or matrix which is to receive the impression of the nibs or casters passes round it. Its journals turn on wheels fixed in the case of the instrument. It is provided on its right side with a cog-wheel actuated by another driving wheel, to be hereafter described. It is of the same length as the keyboard, and sets in motion at its lower part two rollers, one of which carries the paper away into the lower part or case of the piano, while the other, of smaller size, acts simply as a guide in its fall. The first roller is of special construction, so that the impression of the nibs may not be blotted when the paper passes between it and the cylinder. Counterbalancing levers, the principle of which will be hereafter explained, run along the top part of the printing cylinder; these levers are done away with when the casters are used. The paper or matrix is supplied from a box at the back of the cylinder, and is self-unwinding.

The Motive Power.—The motive power is a clockwork. It is designed to communicate a uniform movement to the apparatus, and is fitted to effect this with a regulator specially constructed. The counterbalancing levers — the explanation of which finds its place here—are situated on the top part of the cylinder, and resting upon it, are actuated by the notes of the keyboard. The weight of these levers on the cylinder is equal to the pressure transmitted from the note when actuated upon through the transmitting hammer and nibs to the printing cylinder, so that when the nibs come into contact with the latter, the weights of the levers thus set in motion lift off the printing cylinder, and the equilibrium between the motive and resisting power is thus maintained, and the movement therefore keeps uniform. The transmitting hammers are besides constructed so that the pressure on the cylinder should always be the same whatever might be the effort produced on the note.

Noting Apparatus.—This apparatus is divided into three parts: a board, the notes indicator, the metronome apparatus. The board forms the front part of the top of the piano, and can be lowered when wanted, so as to be used as an office desk or a drawing-board. The paper or matrix lies closely against its upper surface. The left-hand side of the board is fitted with a notched brass rule. The notes indicator is a flat sliding rule similar to the ordinary drawing rule. Longer than the keyboard, it is divided on both sides into parts corresponding to the notes of the keyboard, and is noted accordingly. On one side are shown the sharps and naturals, while on the other are shown the flats and naturals. The left part of the rule—painted blue—represents the key of F, the right part—painted red—the key of G. The musical staves are shown on the rule, so that when the copy is proceeded with one knows immediately if the note played is natural, sharp, or flat, with its right position on the staff. Let us take, for instance, the note *d*. On the keyboard it occupies three different positions, *d* flat on the left, *d* natural in the middle, *d* sharp on the right. Notwithstanding this, on ordinary musical paper one single position is assigned to these three different intonations. For any of these three notes played the rule will indicate the fourth line key of G or the third line key of E, as the case may be. A reglet gives the mode in which the piece has been performed—major or minor—with the necessary sharps or flats shown in their position on the staff—key of F or key of G—while another sliding reglet, moving lengthwise on the flat rule above described, hides from view the sharps or flats shown on the staff and sets off the accidentals, whether naturals, sharps, or flats, not belonging to the mode actually played. The copyist can therefore (1) Place *d* on the fourth line of the staff key of G; (2) know whether or not this *d* is shown as sharp or flat at the beginning of the staff, and if being so, that it has been played accidentally as a *d* natural, in which case the rule gives the letter *d* with the conventional sign "natural" written on its right side. This law is a general one, and can be applied to every note, mode, or scale, major or minor, whatever may be the piece performed, either in C major, natural, sharp, or flat, or B flat, major or minor. Besides, the flat rule, by means of a peculiar disposition, allows of an instantaneous transposition of the piece to be copied; such piece having been performed, for instance, in *d* major or minor, can be copied at once in *a* major or minor, and reciprocally, or in any other key.

The Metronome Apparatus.—This apparatus gives the values of notes and rests. It is situated on the foremost part of the noting apparatus, to which it is fixed, and can be pushed forward as the rule moves on the board. It is composed of two series of wheels and of a revolving dial. The first series consists of thirty-two toothed wheels of different diameter resting on a common shaft movable lengthwise, upward, and downward. Each wheel, the number of teeth of which has been calculated beforehand, corresponds to a certain number of the metronome. Maëlzel, No. 60, which gives one vibration to a second having been taken as a unit. The wheel corresponding to the number chosen by the performer is then used by the copyist, and placed accordingly on the notched brass rule running alongside the board. The shaft of the fusee, besides the thirty-two wheels mentioned, is provided on its left end with a driving wheel setting in motion a second series of three wheels resting on a common axis. These three wheels of calculated diameter, and also movable lengthwise, upward, and downward, are used in the copy for indicating the beat or time in which the composition has been played, whether in $\frac{4}{4}$, $\frac{4}{8}$, or $\frac{4}{16}$. At the further end of this axis is a revolving dial fitted with a proper hand, showing in numbers the value of notes from the semibreve and fractions down to the double demisemiquaver, and of rests from the pause and its fractions down to the sixteenth of the crotchet rest. The dial makes one complete revolution for twice the beat or time in which the composition has been played, whether in $\frac{2}{4}$, $\frac{2}{8}$, or $\frac{2}{16}$. The annexed engravings are reproduced from photographs of the instrument itself. The apparatus described has been, as we have said, invented by Mr. A. P. Hodgson, and constructed by the firm Ch. de Rohden, of Paris. It is patented in every country.

Theoretical Description of the Working of the Apparatus. Theory of Values and Rests.—The units adopted in music are the semibreve for notes and the pause for rests. They are each represented by four vibrations of the pendulum. The working of the instrument is based upon this simple mechanical law, that "spaces covered are proportionate to the time in which they are covered." If for a certain time t the space traversed by the cylinder is s, and if we call n the number of vibrations of the pendulum, we should have the proportion $\frac{t}{n} = \frac{s}{n}$. Let us now suppose t equal to four vibrations of the pendulum, and the cylinder set in motion, calling s the space covered during that time, it will then be equivalent to the semibreve or its fractions according to the value of t. What is said for the semibreve and its fractions may be applied to the pause and its fractions, with this difference, that the musical stroke on the cylinder will be replaced by proportionate empty spaces or intervals. Thus it will be seen that the double demisemiquaver and the double demisemiquaver rest, being the sixty-fourth part of the semibreve or pause, the space covered on the cylinder will be represented in both cases by $\frac{s}{64}$ equivalent to $\frac{t}{64}$. Then for one certain position of the weight of the pendulum the copy of values, of notes, and rests can be easily made. But as every one knows, the semibreve and pause may change indefinitely, according to the variations of the unity of movement; that is to say, according to the position of the weight of the pendulum. Let us take, for example, the weight distant from the axis of suspension of the pendulum equal to $\frac{1}{m}$, the space or s covered by the cylinder during the time $\frac{t}{m}$ will be $\frac{s}{m}$, that is to say, that s, or the unit of space representing the semibreve, varies proportionately with every value of m. To obviate this difficulty one out of two contrivances might have been resorted to. The first one would have been to provide the motive power of the apparatus with a movable fusee, that is to say, with a set of toothed wheels of different diameters acting separately and at will upon the wheel or pinion of the printing cylinder, so that the space covered should have been always the same or s would be invariable, whatever might have been the value of m. The second contrivance, which is the one adopted in the instrument as being less difficult of execution and more practical, has been to do away entirely with the fusee in the motive power, and to have it shifted to the noting apparatus, rendering at the same time s variable for every position of the weight of the pendulum or every value of m. In the first instance the speed of the cylinder was variable according to the piece performed to have s invariable, in the second one the speed of the cylinder remains invariable to have s variable. For m equal to 1, 2, 3, 4, etc., the copyist has only to choose the proper wheel of the fusee corresponding to the movement of the piece performed, as indicated on the apparatus itself, and so on for every value of $\frac{1}{m}$. The number 60 of Maelzel's metronome giving one vibration to a second; this number multiplied by four, with the position of the weight of the pendulum corresponding to $m = 1$, has been taken as a unit of movement equivalent to the semibreve or pause; and is the basis of the instrument.

Theory of Intonations.—In order to simplify the noting apparatus for intonations, the pianograph does not admit more than thirty modes, twenty-eight being diatonics and two chromatics, that is to say, that any natural mode—major or minor—for each tonic may be altered by taking the same tonic *less* a semitone, and not *plus* a semitone. Let us take, for instance, *d*. The instrument will show *d* natural, major or minor, and *d* flat—*d* less a semitone—major or minor. It sets aside *d* plus the semitone, or *d* sharp, as uselessly complicating the noting process. Besides, it follows in this respect the rules of ordinary musical notation—*d* sharp major or *d* sharp, *e* sharp, *f* double sharp, *g* sharp, *a* sharp, *b* sharp, *c* double sharp, *d* sharp, gives two double sharps, *f* and *c*. It is therefore much more simple to have *d* sharp major suppressed altogether and to take in its stead *e* flat, or *e* flat, *f g a* flat, *b* flat, *c d e* flat. This latter mode, though different theoretically, is not so practically, as one can easily see by comparing the two *e* flat, as any other note in the pianograph is considered as *e* natural less one semitone, and *e* sharp is *e* natural plus one semitone. As scales proceed by tones and semitones in the following order for major keys 2 . ½ . 3 . ½, and for minor keys 1 . ½ . 2½ . 2, and besides, the distance between every axis of each note on the keyboard being invariable, it has been possible to contrive the noting apparatus accordingly, so that the instrument should indicate: First, the key in which the piece has been played, with the necessary sharps and flats on the staves; secondly, the natural notes; thirdly, the accidental notes; the whole of the system being based on the tonic or final note shown on the printed paper or matrix. The pianograph establishes no difference of sounds as given by the vibration of a sonorous string between a diminished chord or an increased one—that is to say, that a major third when diminished giving *e* flat and the second major increased giving *d* sharp, there is no difference in the printing process between *e* flat and *d* sharp; and further, any accidental notes, sharp or flat, are shown by the instrument as *sharp* if the piece performed is in a sharp or natural key, and as *flat* if the piece has been played in a flat key, whether the chord is an ascending or an inverted one. Let us take, for instance, a piece played in *c* natural with an accidental chord *d, f* sharp, *a*. the inversion of which is *d, a, f* sharp, in both cases we shall have *f* sharp instead of *g* flat given by the instrument; the sound being the same on the pianoforte, the composer is afterward at liberty, if he thinks proper, to alter the sign in the copy according to the laws of harmony, though practically there is actually no difference. The same can be said of any upward or downward scale, either diatonic or chromatic. This general rule can thus be set down: That in the pianograph for every mode or key indicated as sharp or natural on the staves, any accidental notes or chord in the course of the piece performed will be shown as *sharp*, and for every mode or key indicated as flat on the staves any accidental note or chord will be shown as *flat*.

With this apparatus the composer has only to play what he pleases. The printed paper produced will enable any clerk to produce the composition in the shape of ordinary written music sheets.—*The Engineer.*

DISTRIBUTION OF DARK HEAT.

P. DESAINS has investigated the distribution of heat in the obscure region of the solar spectrum. The diathermancy of the air is continually varying on account of the variable degrees of moisture which it contains. The radiations of the luminous part of the spectrum are only slightly absorbed, but the dark rays are largely so, and in a ratio which generally increases with the length of the wave. In order to measure these influences, the observations have been compared with others upon the transmissibility of the total solar heat through a uniform thickness of water. Prisms of flint and crown glass and rock salt, of which the indices have been accurately determined, are employed in these measurements. Desains has already obtained data which enable him to construct the curves which represent the distribution of heat in the dark spectrum, and he proposes soon to publish some valuable comparative results.—*Comptes Rendus*, civ., 1144.

RELATION OF EXPERIMENTAL PHYSIOLOGY TO PRACTICAL MEDICINE.*

By G. F. YEO, F.R.C.S., PROFESSOR OF PHYSIOLOGY IN KING'S COLLEGE.

UNTIL within the present century it was the practice of surgeons to cut down on and divide the portio dura of the seventh pair of nerves, at its exit from the parotid gland, in order to cure neuralgia of the face. This operation caused loss of *motion* of one side of the face, without in the least influencing the pain, for this nerve has nothing to do with the transmission of sensory impulses. This useless proceeding was even continued for some time after Sir Charles Bell had shown the real function of this nerve.

This same nerve is often more or less completely deprived of its function by pathological processes of different kinds. The result is the well-known facial paralysis. Its various causes may affect different parts of the nerve, within the cranium, in the petrous part of the temporal bone, or in the more superficial portion on the side of the face. In each of these situations the prognosis and the treatment should be different, and their differential diagnosis is therefore essential before a rational treatment can be determined. The key to this difficulty lies in what we have learned from vivisection, combined with an exact knowledge of anatomy. There are certain branches that spring from different parts of the nerve whose functions are known to us only as the result of vivisections—*e. g.*, the chorda tympani nerve, which bears secretory impulses from the brain to the submaxillary gland, and the lesser superficial petrosal branch, which carries taste impulses from the tip of the tongue to the sensorium; these come off from the nerve in its passage through the temporal bone. If, then, a bitter substance applied to the tip of the tongue on the affected side fail to produce a bitter taste, and if weak acetic acid do not produce a flow of saliva from the gland on the affected side, the lesion must implicate the origin of these branchlets, and therefore be deeply seated.

Again, it is to vivisection that we owe the introduction and the perfection of the operation of transfusion as a mode of treatment. By experiments on dogs Lower first demonstrated and made well known to the scientific public, in the seventeenth century, the possibility of replenishing the blood of one animal by that taken from another. I am aware that the claim of priority concerning the operation of transfusion is disputed. Dr. Ogle, in his Harveian Oration, has distinctly shown that the story of the transfusion of the blood of the three boys into the vessels of Pope Innocent VIII. is not to be accepted, the repeated mention of it being merely from hearsay. A description of how the operation might be performed is given by Libavius, the chemist of Halle, but he severely condemns its practice. But whether Libavius did it himself or not, and the former supposition seems very questionable, there can be no doubt that it had been often carried out on the lower animals before it was attempted on man. In more recent times many improvements have been made in the operation by vivisections. For instance, it has been shown that freshly defibrinated blood is as efficacious and as safe as that from which the fibrin has not been removed. Moreover, the danger of using the blood of dissimilar animals was shown, and surgeons were thus warned against a mode of practice that at one time had proved a great drawback in the adoption of the operation, for it made the result very uncertain. Thus we see that whoever first actually performed the operation, it was by experiment on the lower animals that a method of saving life in cases of severe hemorrhage was placed in the hands of the surgeon, and by the same means its application has been robbed of its chief dangers, so that by it a large number of human beings have been rescued from bleeding to death. But this wonderful means of saving life is not applicable to cases of dangerous bleeding only. In charcoal suffocation we know—chiefly by experiment—that of the noxious gases evolved by the burning charcoal, one, carbon monoxide (CO), acts differently from the other, carbon dioxide (CO_2). In the former case the gas forms a stable compound with the coloring matter of the blood, not only replacing the oxygen which the hæmoglobin normally carries, but also preventing the future union of that gas with the blood corpuscles. The blood in which the hæmoglobin is combined with carbonic monoxide is of a brilliant scarlet color, unlike that of carbonic acid poisoning, or of ordinary suffocation, in which case it is dark. In pure carbonic acid poisoning artificial respiration is most useful, and, as a rule, will suffice to restore the reduced hæmoglobin to its natural oxygenated state. In poisoning with carbonic oxide, on the other hand, experiment has taught us that artificial respiration is useless, and that the permanently spoiled hæmoglobin must be got rid of by bleeding, and fresh blood supplied in its place by transfusion. In calculating the value of transfusion it must be remembered that it really is a means of saving life rather than a mode of treatment, for it is only employed as a last resource in otherwise hopeless cases. In fact it brings back to life one practically dead. Yet I find that more than half of the recorded cases in which it has been used have been successful, and the dying patients have been saved from a sudden and certain death. The following table gives the result of 216 cases:

	No. of cases treated.	No. cured.	Per cent. cured.
Post-partum hemorrhage...	108	 63	... 58
General hemorrhage.....	75	 38	 50
Intestinal hemorrage.....	18	 10	 55
Carbonic oxide poisoning..	15	 0	 40

I shall not enumerate the many operations—otherwise impossible—which the use of aseptic surgery has enabled the surgeon to perform, although we may in a great measure claim antiseptic remedies as the direct outcome of experiment on living animals. There are, however, several surgical operations which owe their origin or application so directly to experiments on the lower animals, that they must be alluded to, however briefly. The operation for amputation through the hip-joint was performed on dogs, and on its success being reported to the French Academy, it was generally applied in military surgery to the human subject. Of its feasibility as an operation there is now no doubt. The improvements in orthopædic surgery which, though recent, are now regarded as a matter of course, chiefly depend on the physiological investigations which Stromeyer, v. Ammon, Bouvier, Guérin, and others carried on in this century. Tenotomy was hazardous and unsatisfactory in the extreme until the subcutaneous method was perfected and the mode of repair of tendons fully investigated upon the lower animals by the authors just named and many others. So much has already been said about

* Lecture delivered at the Royal College of Surgeons, June, 1882.

Hunter's experiments in relation to the operation for aneurism, that I shall content myself by reminding you that they have a direct bearing on many methods used in modern surgery in general, and that they were not merely useful in leading to one mode of curing aneurism; and further, that, no matter who first tied the artery above an aneurism to accomplish its cure, such a proceeding was only made justifiable by the knowledge of the circulation which was acquired by vivisection.

There are many operations which have been performed on the stomach and the other abdominal viscera which are the outcome of vivisection. So long as thirty years ago Sédillot was tempted by the facility with which Blondlot established gastric fistula in dogs, for the purpose of making experiments on digestion, to perform a similar operation on a human being. Having under his care a case of cancer of the œsophagus, in which life was threatened from inanition, he determined to open the stomach. He did so according to the rules of experimental physiology, and possibly prolonged the patient's life, and certainly improved his condition while he lived. Since then Billroth has removed a portion of the stomach for cancer. And Czerny, of Heidelberg, has removed a cancerous tumor involving the pylorus of a man who seemed to be rapidly sinking from the occlusion of the outlet of the stomach and constant vomiting. In a little more than a month after the operation the man increased nearly a stone in weight, and then returned to his work. More striking still is the case of a healthy young girl, who by accident swallowed some corrosive poison, and recovered from its immediate effects. The œsophagus was so much injured that swallowing was out of the question, and even the introduction of food through a tube was attended with great difficulty. The awful death of slow starvation was the only prospect before this otherwise robust girl. She was operated on in exactly the same way as experience had shown was the safest to establish a gastric fistula in a dog. She now feeds herself, and enjoys life. Here, then, is a simple answer to the statement that "not one benefit has accrued from the labors of the physiologist, either to medical or surgical science?"

Wounds of the intestine have always been regarded with great dread by surgeons. By an experiment on a dog it was shown that by securing the union of the serous surfaces a portion of the intestine could be removed, and the ends of the remaining portion sewn together so that the peritoneal surfaces united. Since the original experiment of Shipton, a young Englishman, similar operations have been frequently performed on animals for the purpose of collecting the intestinal fluids. Upon the same principle wounds of the human intestines have frequently been caused to unite, and, as Mr. Benjamin Travers has shown, by this means much of the horror formerly attached to strangulated hernia has been dispelled.

There is further a surgical instrument which, in special cases, is of great value, the invention and applicability of which was aided by experiments on lower animals. M. Chassaignac was led to imagine, on *à priori* grounds learned from surgery, that a torn tissue would not bleed as it would when cut with the knife; but humanity forbade his at once applying his theory to human beings; so he first used his écraseur upon dogs. He says, in describing experiments made on the tongue of these animals: "When the crushing was conducted slowly, the solution of continuity was dry; there was no hemorrhage, either primary or secondary." I have seen M. Chassaignac in his hospital practice sit with most exemplary patience slowly applying the rules he had thus learned from vivisection to the removal of tumors which the knife could not have reached.

In many cases where disease of a bone or joint used in former days to demand the removal of the limb, the bone or the joint now only is removed, and the rest of the extremity—a sound hand or foot probably—is left to the patient. This change in practice was in a great measure brought about by the knowledge of a fact which was derived from experiments on living animals. In the last century Duhamel clearly proved the mode of growth of bone, and placed beyond a doubt the fact that the periosteum can produce bone; and Michael Troja showed by experiment the more accurate details of the process long before subperiosteal operations were thought of for the alleviation of human suffering. Nearly fifty years ago Mr. Syme made experiments on animals on the subject of the formation of bone from periosteum, and showed the immediate application of his results to surgical practice. In 1867, M. Ollier, of Lyons, made a more elaborate work on the subject, which brought the matter prominently forward. Probably there is no point which has contributed more to the advance of "conservative surgery" than this. Whether an elbow be flexible or rigid after its excision, or whether a limb be too short or distorted after the subperiosteal resection of the bone, it is an inestimable gain to retain a living and moving hand instead of a stump-hook.

The fact that a dog can live in the enjoyment of perfect health after one kidney has been removed has often been established in physiological laboratories. This operation has now frequently been performed on the human subject, and repeatedly with success in cases where all other means of prolonging life or making it bearable had failed.

A case occurring in his clinique, in which malignant disease of the larynx threatened a man with immediate and sudden death, Billroth conceived the idea of removing the entire organ. One could hardly do such a terrible operation, even on a dying human being, without some kind of experience to instruct and guide one. Accordingly, Czerny, who was then his assistant, did the operation successfully on a number of dogs, and thereby gained such knowledge as to enable Billroth to carry out his intention. He operated, and the patient recovered, and with an artificial larynx could breathe and even speak in a whisper.

The whole history of our knowledge of inflammation is so interwoven with experiments on living animals that I could not attempt in the short space of an hour to trace out the many and great obligations that pathologists owe to vivisection for elucidating the minute changes in this process. I need only refer to the experiments of Hunter, Thomson, Wharton Jones, Paget, Virchow, Lister, Cohnheim, Stricker, and others, who have made this important topic a special subject of study. Nor will time allow me more than to name the application of experiment on the lower animals to the infectious diseases and the febrile state in general. The result of Koch's work on the infection from wounds and splenic fever, and Pasteur's beautiful researches, not only form strong rocks of defense against the clamorous ignorance of those who prefer mystic to common sense and sentiment to rational modes of treatment, but they also afford great encouragement for the future of experimental research by showing what results may thus be attained.

With regard to remedies suggested, or discovered by vivisection, it must be remembered that experimental therapeutics as a science is in its infancy, and therefore their number is not great. There are, however, some very important drugs which owe their introduction into medicine to experiment on the lower animals. Much has been written and said about the few remarkable cases in which drugs have a different effect on some animals from that which they exercise on man. It must be remembered that these are rare exceptions, and only occur in the case of a few animals, so that by using animals of different species the probable effect of any medicament on man may be determined with sufficient certainty for its efficacy on the human subject to be tried with impunity. It is generally the experimenter himself upon whom this trial is first made. Among the drugs which we certainly owe to experiment on living animals—such experiment as would come under the act, though not really vivisection—is chloral hydrate. From the chemical composition of the substance Liebreich thought that it would have much the same effect as chloroform, and he found by trying it on rabbits and other animals that such was the case. It induces sleep, and in larger doses destroys sensibility. In large doses it affects the heart and lowers the animal heat so as to become dangerous. When used to prevent pain in operations on the lower animals care must be taken to keep the temperature from falling, and this should be remembered in treating cases of poisoning by this drug. We know from vivisection that the alkaloid of deadly nightshade, atropin, checks the secretion of saliva. Often in cases of paralysis, and sometimes in fracture of the skull, dribbling from the mouth is a most distressing symptom; it saturates the pillow and robs the poor patient of much needed rest. A little atropin injected under the skin in the neighborhood of the gland checks for hours the flow of saliva, and enables the sufferer to enjoy a quiet sleep. But belladonna is a dangerous poison, acting, as vivisection shows, by depressing the heart-nerves; but it has also been demonstrated that a substance which can be extracted from a bean used in Calabar as an ordeal poison, has an antagonistic influence on the nerves of the heart, and acts as an antidote in cases of belladonna poisoning.

We know further from vivisections that a substance called amyl nitrite causes general relaxation of the blood vessels. It has therefore been used with success in cases of headache arising from spasm of the cerebral vessels, and has been found of more value in that agonizing disease called angina pectoris than any other known remedy. The alkaloid of nux vomica, strychnia, was also introduced into practice by experiments on the lower animals, and its remarkably stimulating effects on the spinal cord were made out by Magendie. It is now in common use, and is recognized as a valuable nerve tonic. Strychnia is known to be a terrible poison, but the alkaloid of tobacco, nicotin, has been put forward as its antidote by Professor Haughton, from the experiments which he performed on living animals. For a very long time the occurrence of sugar in the urine has been recognized as the chief symptom of diabetes. The mechanism of its production and the locality where the sugar was formed, were alike unknown until Claude Bernard determined the glycogenic function of the liver. We now know that any disturbance of the vaso-motor mechanisms of that great gland causes an excess of sugar to appear in the blood and be eliminated by the kidneys. This is at least a step toward the pathology of this disease. By vivisections we know further that the production of sugar depends upon the presence of a ferment which changes the normal glycogen into grape sugar. Is there nothing that will check this process and save the economy the great loss of sugar? From experiments by Lemaire we learn that carbolic acid checks fermentative changes. Relying on this and other information acquired by vivisection, carbolic acid has been tried internally in some cases of diabetes, and in a certain number of these cases the sugar has disappeared from the urine.

Although I have enumerated these special instances in which vivisection has directly benefited practical medicine and surgery, I do not wish to lay stress upon them as the strongest evidence in favor of the necessity of experimental research. I must once more insist that the immediate object of physiology is not to invent cures for disease, but to learn the normal operations of the living economy. If we could remove from our thoughts of a case of disease the memory of even one of the great facts which form the basis of our physiological knowledge, which have been derived from vivisection, and if then we attempted to arrive at the diagnosis, prognosis, and treatment of the case in question, we should find that the entire fabric upon which we base our arguments would collapse like a house of cards from which one card from beneath has been roughly withdrawn. In his evidence before the Royal Commission the venerable Professor Wm. Sharpey said: "I think that vivisection is of value as promoting the science of physiology, and that again is one of the great foundations of all rational medicine. . . . It puts a lamp, so to speak, in the hand of the physician when he is studying disease. . . . In short, I should say that physiology is not to be compared to a reaping-machine, but rather to the plow."

Rational therapeutics must grow out of physiological knowledge, as surely as a plant is the outgrowth of its roots. As the remote rootlets are the exact parts which are all important for the nutrition of the plant, so experiment feeds physiology and thereby nourishes the art of medical practice. It would appear silly to ask to what rootlet any single fruit or flower on a widely-spreading tree owed its existence or nutrition, and so it is idle to expect that each, or even any, therapeutic agent or method of diagnosis should be traced to the definite experimental discoveries that may have led to its adoption or use. As the branches of our medical tree spread wider and wider, and its diagnostic flowers and therapeutic fruits become more and more numerous, we find that its physiological roots go deeper and deeper in search of pabulum, and the experimental rootlets become still further removed from the more obviously useful and prolific part of the plant.

ROASTING ZINC BLENDE AND NEUTRALIZING THE GASES BY MEANS OF SOLUTION OF CALCIUM SULPHIDE.

By Dr. KOSMANN.

THE author first refers to Schnabel's process, in which the sulphuric and sulphurous acids of the gases from roasting metallic sulphides are absorbed by means of basic zinc carbonate, or by a mixture of zinc oxide with basic zinc sulphate. The process is technically successful, but the quantity of the absorbent material required is a fatal obstacle from a commercial point of view. For every per cent. of sulphur in the blende which is roasted two and one-half times the weight of zinc oxide must be used. Hence, for a blende containing 40 per cent. and 20 of sulphur, every kilo requires 0·5 kilo of zinc oxide. The removal and renewal or calcination of such quantities of the absorbent consumes too much labor and capital. The calcium sulphide process is described at length. The absorbent liquid is an aqueous solution of calcium monosulphide. It is found, however, that the product obtained by igniting a mixture of gypsum and coal contains not merely the monosulphide, but if it has been exposed to the air, polysulphides along with calcium hydrate. It has since been found preferable to prepare the solution by boiling sulphur with milk of lime. Here also polysulphides are present, but in a dilute lye, and in presence of calcium hydrate they pass into calcium sulphhydrate. Along with the polysulphides calcium hyposulphite enters into solution, which also serves for the neutralization of the sulphurous gases. The products of the absorption are free sulphur and gypsum. From 50 to 58 per cent. of the sulphurous acid of the gases are absorbed.

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